South East Asian Studies, Vol. 16, No. 4, March 1979

Effect of Mekong Mainstream Flood Regulation on Hydrology and Agriculture in the Cambodian Lowland (I) : Rice Culture*

Yoshihiro KAIDA**

Introduction

1 *Objective of Study*

Assuming the capability of the proposed Mekong mainstream reservoir, Pa Mong, to control floods in the Cambodian part of the Mekong delta to be as calculated from hydrologic analysis, the major purposes of this study are (a) to estimate the area in the delta that could be reclaimed for agriculture, and (b) to evaluate possible improvements in existing delta agriculture which would result from the changed water conditions.

2 *Background of Study*

Cambodian agriculture is at the mercy of natural hydrologic conditions, the agricultural lands being either in the low-lying floodplain and exposed to serious danger of floods by the Mekong waters, or upland terraces constantly threatened by recurrent, prolonged drought. Mekong floods are uncontrollable in the flood season and lands become extremely desiccated in the dry season. Prospects for improvement of Cambodian agriculture seems to depend upon regulating of these extreme anomalies in hydrology.

The Mekong river, which flows through major parts of the Cambodian lowlands, is one of the biggest rivers in Asia having a drainage area that includes a part of China, Burma, Lao PDR, Thailand, Cambodia and Vietnam, and is of an area of 646,000 km^2 at Kratie (in Cambodia, 550 km from the sea), and 795,000 km^2 at the river mouth, this latter being about double that of the Japanese Islands (Ref. 2). The flow volume in the rainy season rises to ca. 60,000 m^3/sec, and decreasing to ca. 1,500 m^3/sec at the end of the dry season. The river-bed slope becomes extremely gentle in its lower reaches being on average 1:16,000 from Vientiane, Lao PDR to river mouth, and 1:30,000 in the delta region downstream from Kompong Cham in Cambodia (see Fig.1 for comparison with a few major rivers in Japan). The extremely high water flow in conjunc-

* This paper is principally based on the author's previous study "Pa Mong Downstream Effects on Hydrology and Agriculture in Democratic Kampuchea" which was carried out when he served the Mekong Secretariat during 1974–77. The author acknowledges the kind approval by Mr. W.J. Van der Oord, Executive Agent of the Mekong Secretariat and Dr. W.J. Van Liere, Acting Director of Agriculture Division, Mekong Secretariat of his revising, rearranging and rewriting of the original version of this paper (Ref. 1).

** 海田能宏, The Center for Southeast Asian Studies, Kyoto University

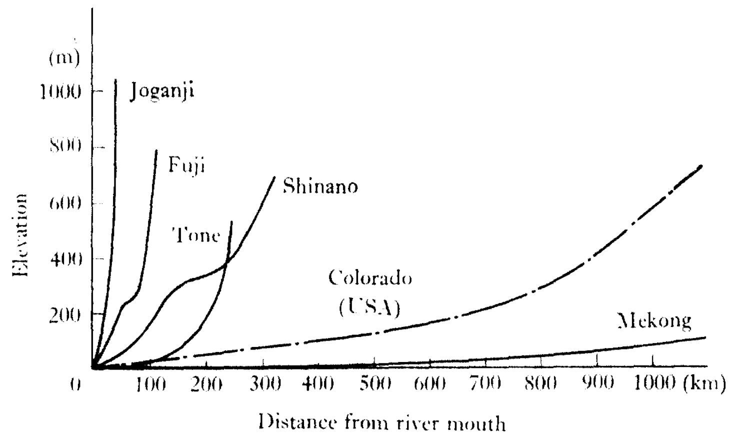


Fig. 1 River-bed Slope of the Mekong as Compared with Several Major Rivers in Japan and the United States (Ref. 16)

tion with the very gentle slope of river-bed causes severe floods in the river floodplains. The river overbanks at Kratie (near the apex of the Cambodian part of the Mekong delta) eight years out of ten. The water regime not only causes severe flood damage to agricultural crops but also constrains the pattern of crop cultivation.

In order to harness the vast water resources and control the mighty force of the Mekong, the Mekong Committee (Committee for Coordination of Investigations of the Lower Mekong Basin) and its Secretariat have, over the last three decades been putting considerable time and effort into collection and analysis of data concerning the resources of the basin and into river development planning work. In the case of the mainstream project the studies and planning work resulted in the idea of building a huge reservoir, one of the largest in the world, at Pa Mong, about 25 km upstream of Vientiane and on the national border of Lao PDR and Thailand, which would thus bring about revolutionary change to various aspects of the whole lower basin. Major benefits that would result from Pa Mong project are expected to be as follows (See Fig.2):

Northeast Thailand	Hydro-power production (ca. 4,800 MW), irrigation development (up to ca. 1.2 million ha), and complete flood control (ca. 100,000 ha of agricultural land).
Lao PDR	Hydro-power production (ca. 4,800 MW), irrigation development (ca. 200,000 ha), and complete flood control (ca. 100,000 ha).
Cambodia	Possible flood relief influencing ca. 400,000 ha of agricultural land.
Vietnam	Low flow augmentation of the Mekong in the dry season, and partial flood relief.

It is quite obvious that individual mainstream projects for this international river cannot be planned and implemented unless full consent is reached by the four riparian

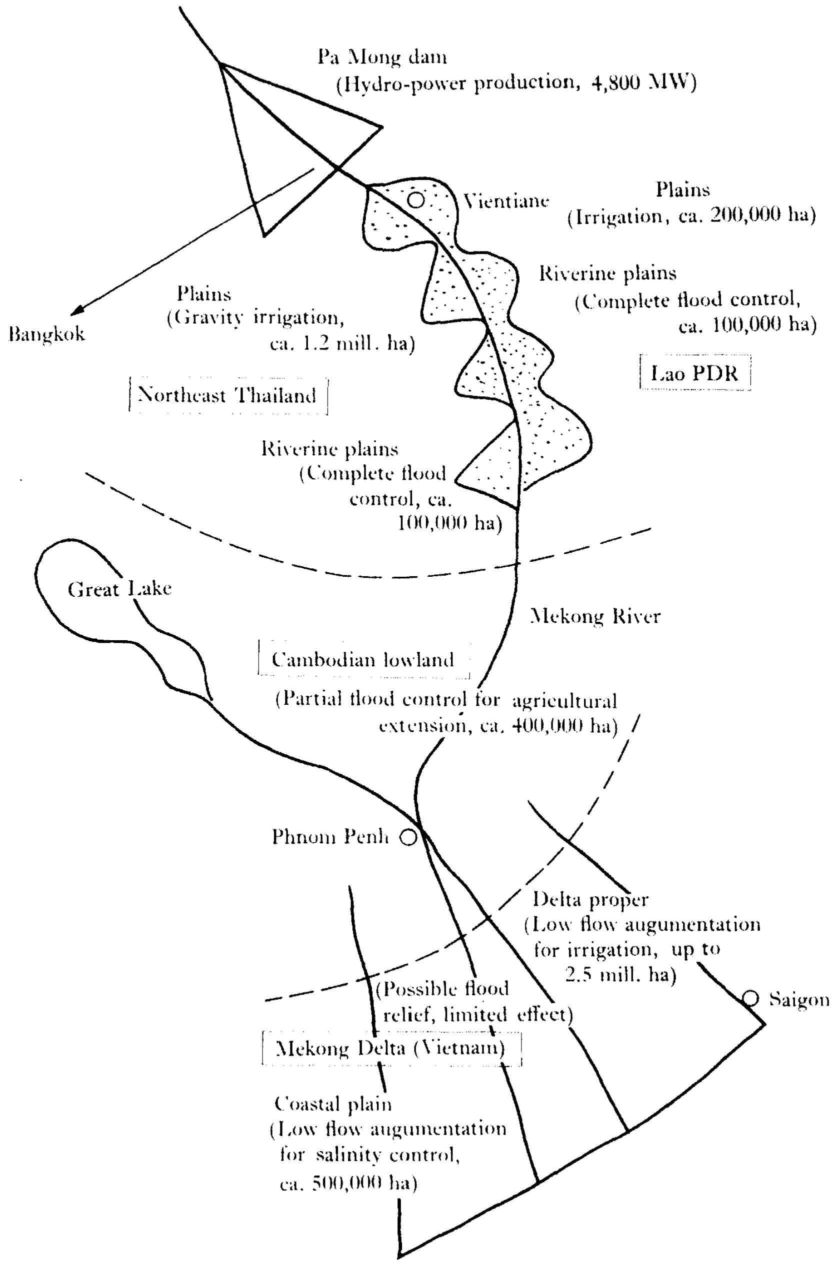


Fig. 2 Schematic Chart Showing the Possible Benefits from the Pa Mong Dam Construction in the Lower Mekong Basin

countries as to reasonable and equitable benefit for each country.[1] Hence the Mekong Secretariat initiated the Pa Mong Optimization and Downstream Effects Study in which efforts were directed to determining the optimum height and mode of operation

1) Joint Declaration of Principles for Utilization of the Water of the Lower Mekong Basin (Mekong Committee, Signed on January 1975) states, in Article V, "Individual projects on the (Mekong) mainstream shall be planned and implemented in a manner conducive to the system development of the (Mekong) Basin's water resources, in the beneficial use of which each Basin State shall be entitled, within its territory, to a reasonable and equitable share..." (Ref. 4)

of the dam, and to quantifying, as far as possible, every possible effect of Pa Mong on downstream features including flood control, irrigation and other water uses, agriculture, fisheries, navigation improvement, river channel degradation, various environmental impacts of the project, etc. (Ref.3). Thus the present study was intended partly to give meaningful inputs to the optimization study by quantifying the impact of Pa Mong on hydrology and agriculture in the Cambodian part of the Mekong delta, an area for which no such studies had previously been made.

3 *Importance of Lowlands for Cambodian Agriculture*

It is relevant to discuss the importance of lowlands for Cambodian agriculture, since the current study is concerned mainly with the potential for reclaiming lowlands for cropping or for more intensive cropping.

The agricultural lands of Cambodia can be classified into subregions taking into account background information such as topography, soils, hydrology, and natural vegetation as well as present agricultural practices. A delineation of the agro-environmental subregions is shown in Fig.3.[2)]

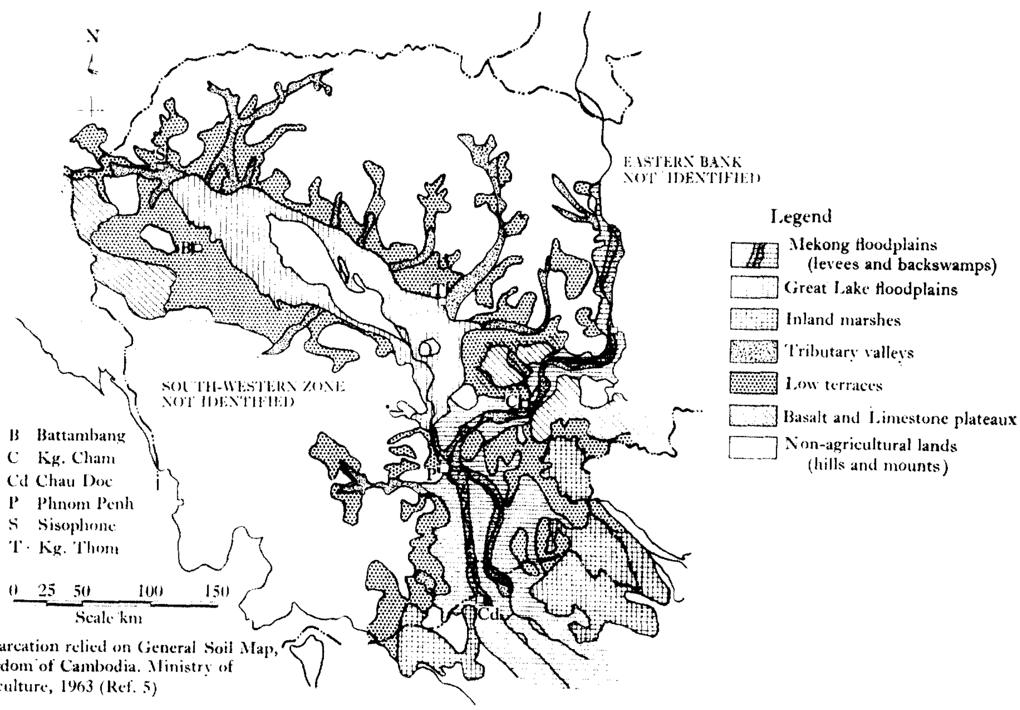


Fig. 3 Agro-Environmental Subregions of Cambodia

These agro-environmental subregions are:

Mekong floodplains (levees and backswamps)

Great Lake floodplains

Inland marshes

2) The demarcations are based primarily on the "General Soil Map, Kingdom of Cambodia," Ministry of Agriculture, Phnom Penh, 1963 (Ref. 5).

Tributary valleys

Low terraces

Basalt and limestone plateaus

For the sake of discussion the above subregions may be regrouped into two major zones, uplands and lowlands. The uplands are composed of terraces, basalt and limestone plateaus, and tributary valleys while the lowlands consist of floodplains and inland marshes. Water is the dominant factor differentiating the two zones. The uplands are well drained and subject to water deficiency reflecting the relatively poor rainfall of the region, while the lowlands comprise water collecting areas or water passages subject to floods of prolonged periods reflecting the water regime of the Mekong river.

At present, about 70 per cent of total rice lands are on non-flooded low terraces, and the remaining 30 per cent are in low alluvial plains subject to deep inundation directly from the rivers or the lake.

Most of the historical cities of Cambodia are at the fringe of the low terraces facing the floodplains, and in the past their economies were probably based mainly on agricultural cropping in the low terraces, hence the core area of Cambodia was in the "uplands." However, at the present time, the low terrace soils have deteriorated severely because of yet unknown reasons, and they are now, in general, very poor except for some limited areas of regur and brown hydromorphic soils. Most paddy growing on the low terraces relies on very erratic local rainfall, or on water from relatively small catchment area. Severe drought damage to rice is common and as a result production is very low. For example, average paddy yields on Pleistocene terraces and fans west of Phnom Penh and near Kompong Speu are as low as 800 kg/ha. It would require a huge outlay of investment in irrigation facilities and fertilizer inputs if the uplands of Cambodia were to be improved to become highly productive agricultural land.

On the other hand, the lowlands of Cambodia, which have relatively fertile Recent alluvium, and Recent lacustrine alluvial clayey soils, have not yet been fully developed for agricultural uses, primarily because of adverse water conditions. Not only are the floods severe in the lowlands, as will be discussed later in this paper, they also are higly variable from one year to another. The range of intra-annual variation of the Mekong's water level at Phnom Penh is as much as 8 m, and the inter-yearly variation between low and high flood years is approximately 2 m. The character of agriculture in the lowlands has been necessarily adapted to this water regime of the Mekong, as is indicated by rice varietal adaptations exemplified by floating rice, late maturing deep water rice, and dry season rice grown in the lowest areas, and by the adaptation of the growing season exemplified by elaborate pre-flood and post-flood growing schedules for chamkar[3] agriculture on river levees. Crop damage by floods is very common becuase the occurrence of a flood, its timing and magnitude, are not at all predictable. Once this violent water regime has been relieved to some extent, it will be relatively easy and

3) A Cambodian word equivalent to "sloping land," but in this paper chamkar is used to denote the "levee backslope" towards backswamps.

almost costless, in the low alluvial plains, to develop the land into fairly productive agricultural farms.

4 *Preliminary Analysis*

A purely hydrological computation made by the Planning Unit of the Mekong Secretariat as to the Pa Mong probable effect on the mainstream flood regime at Kratie resulted in Fig.4 (Ref.6). The result shows that even with the tallest dam contemplated at present (i.e. 260 m at maximum pool elevation), the flood discharge would be reduced by about only 15 per cent down to 85 per cent of the unregulated flow; and the present flood regime that overbanks at Kratie eight years in ten (exceeding probability of 15 per cent) would be reduced to one overbank in two years (exceeding probability of 50 per cent). This means that the Pa Mong dam will not be capable of controlling floods, but this relatively slight reduction of flood discharge and stage may have a substantial effect on possible flood relief for agricultural cropping in the deltaic region both in Cambodia and Vietnam in view of very flat topography of these regions.

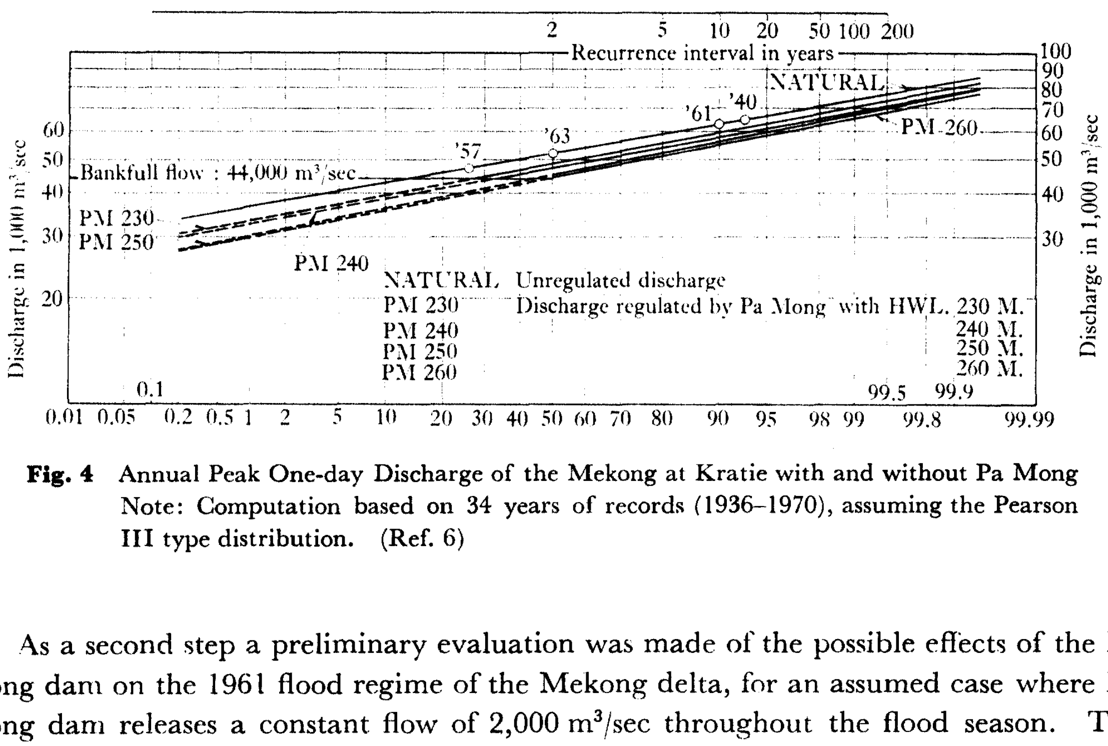


Fig. 4 Annual Peak One-day Discharge of the Mekong at Kratie with and without Pa Mong
Note: Computation based on 34 years of records (1936–1970), assuming the Pearson III type distribution. (Ref. 6)

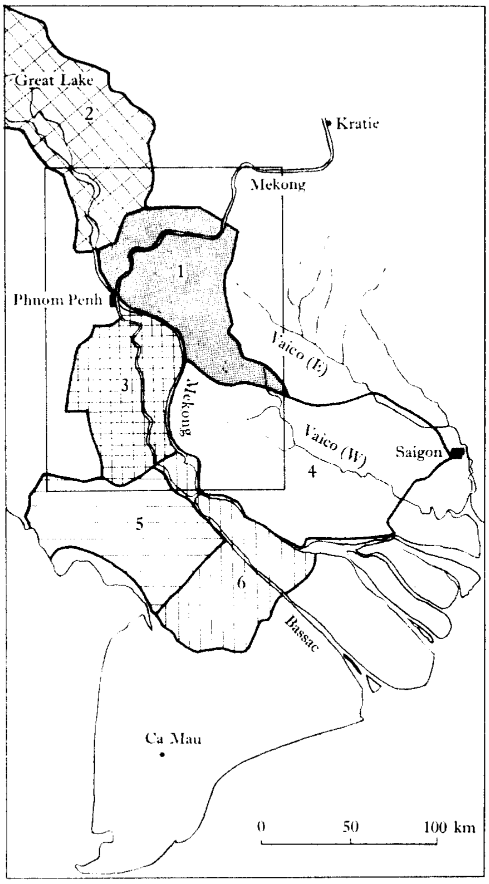
As a second step a preliminary evaluation was made of the possible effects of the Pa Mong dam on the 1961 flood regime of the Mekong delta, for an assumed case where Pa Mong dam releases a constant flow of 2,000 m^3/sec throughout the flood season. The mathematical model of the Mekong delta (to be explained later) was used for this computation. This yielded promising results as shown in Table 1 (Ref.7). The potential floodrelieved areas, although not significant in the Vietnamese delta, were found to be very substantial in the Cambodian delta, as follows:

Great Lake area	184,000 ha
Left Bank of Mekong (Combodia)	147,000 ha
Trans Bassac (Cambodia)	53,000 ha

Table 1 Estimated Area to be Free from Inundation with Pa Mong for 1961 (PM 2000) (Ref. 7)

Unit : 1,000ha.

Region	Left Bank of Mekong, Cambodia	Great Lake	Trans Bassac, Cambodia	Plain of Reeds	Trans Bassac, Vietnam	Cis Bassac, Vietnam	Total
Gross land area	601	1,728	462	852	453	423	4,519
Inundated area (1) Without Pa Mong	493	1,603	375	770	422	418	4,081
Inundated area (2) With Pa Mong	316	1,419	322	725	416	414	3,642
Area to be free from inundation with Pa Mong =(1)−(2)	147	184	53	45	6	4	439



Symbol:
1 Left Bank of Mekong, Cambodia
2 Great Lake (To include the whole Great Lake area)
3 Trans Bassac, Cambodia
4 Plain of Reeds
5 Trans Bassac, Vietnam
6 Cis Bassac, Vietnam

Note: The rectangular area shown in this figure corresponds to the area in Fig. 6

II Procedure of Hydrologic Analysis

The preliminary findings noted above seemed to show very significant improvements to Cambodian agriculture could be obtained by Pa Mong flood control. This indicated the desirability of expanding the study to consider alternative Pa Mong dam heights, and also to consider reservoir regulation as a way of achieving a desirable balance of firm power production and flood control, in order to furnish findings useable in the Pa Mong Optimization and Downstream Effects Study for determining the optimum height of the Pa Mong dam.

To meet this need, the study was expanded to include four possible cases, as follows:

(0) Natural flow without Pa Mong (abbreviated as "Natural");

(1) Pa Mong operated to release a constant discharge of 2,000 m^3/sec throughout the flood season ("PM 2000");

(2) Pa Mong 250 m alternative with the maximum pool elevation at 250 m above mean sea level operated for maximum flood control ("250 MFC");

(3) Pa Mong 240 m alternative with the maximum pool elevation at 240 m MSL operated for maximum flood control ("240 MFC");

(4) Pa Mong 250 m alternative with the maximum pool elevation at 250 m MSL operated for firm hydro-power generation and flood control ("250 P+F").

The "study area" considered coincides with the area covered by the meshes of the mathematical model of the Mekong delta developed by SOGREAH within the boundary of Cambodia (Ref.8,9,10). The area stretches along the Mekong river from Kompong Cham to immediately upstream of Tan Chau and Chau Doc, including the Great Lake area and covering virtually all of the floodable terrain of Cambodia.

The analysis was based on both the micro-hydrologic features and the micro-topographic configuration of the Cambodian delta. The SOGREAH mathematical delta model, a computer simulation model, was utilized to obtain stage hydrographs for each mesh of the region for both unregulated flows and flows regulated by Pa Mong. A detailed contour map (contour interval 1 m) was prepared with the use of 1/50,000 maps and contour maps provided by SOGREAH (Ref.9). Use was also made of the LANDSAT imageries to investigate macro-topographic and macro-hydrologic characteristics of the region.

1 *Hydrologic Analysis*

The SOGREAH delta model can provide detailed outputs on stage hydrographs and interactions of flow volumes between adjacent meshes at specified time intervals, covering all the meshes in the Cambodian and the Vietnamese parts of the delta. The mesh configuration of the model as shown in its topological arrangement is presented in Fig.5. As seen in this figure, the model requires considerable input data (initial and boundary conditions) as follows:

Daily rainfall and evaporation records:	65 stations grouped in 18 parts
Daily discharge records:	16 stations
Daily stage records:	30 stations
Initial conditions (water levels):	293 meshes

A selection was made of four years with different flood levels as test years, namely 1940, 1957, 1961 and 1963, and computer-runs were carried out for the high water period from July 1 through November 30 for each of these years. However, because of the difficulties involved in obtaining the proper data to be used as inputs for initial and

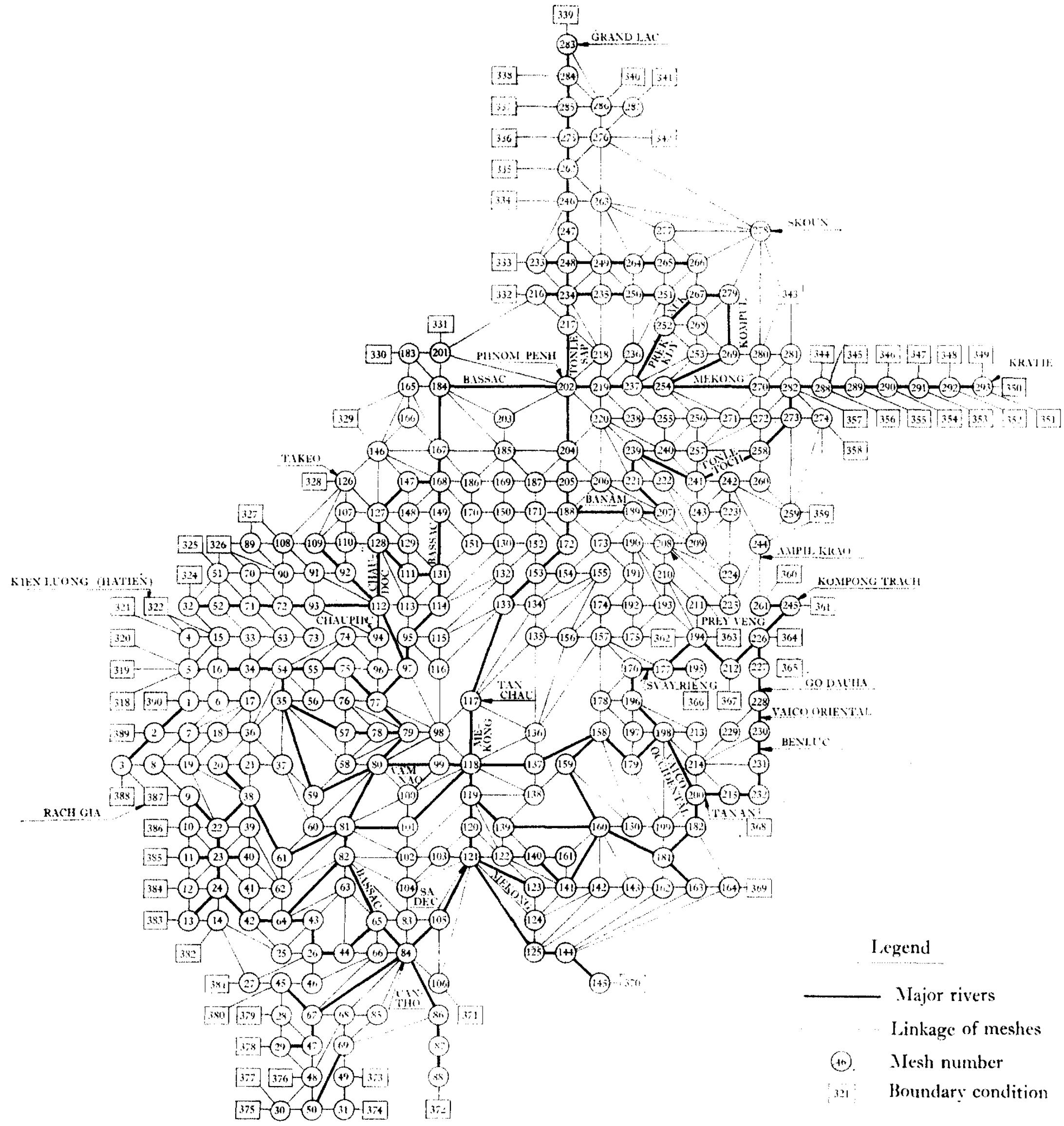


Fig. 5 Topological Linkage of Meshes of the Mathematical Model of the Mekong Delta (Ref. 11)

Table 2 Flood Characteristics of the Mekong at Kratie for the Four Test Years (1940, 1957, 1961 and 1963)

Test years	Peak discharge			Total flood volume[a]			Total overbank flow[b]	
	Discharge m^3/sec	Order in 34 yrs.	Recurrence years	Volume 10^9 m^3	Order in 34 yrs.	Recurrence years	Volume 10^9 m^3	Order in 34 yrs.
1940	64,000	3	15	441	3	15	51.6	1
1957	46,500	26	1.7	318	26	1.6	0.4	29
1961	63,000	4	10	458	2	20	36.8	3
1963	51,000	22	2	359	16	2	3.4	23

a Total flow volume from July 1 through October 31.
b Portion of the total flood volume for which the discharge exceeds $44{,}000 m^3/sec$.

boundary conditions the only available input data ready for the computer model were those for 1961, 1962, 1963 and 1964, except for the major inflows to the model at Kratie. Therefore data for the years 1961 and 1963 were substituted in lieu of the required input data for 1940 and 1957 respectively. Characteristics of the floods at Kratie in the four years are summarized in Table 2.

At first the model was run for each year using the data specified above under the natural Mekong river flow regime. Secondly, the model was rerun with the same input data except for the Kratie inflow, which was now as if regulated by Pa Mong. In this case, a release from Pa Mong, determined by a separate study for each possible case and for different operational policies (flood control, hydro-power generation, or both) (Ref.6), was routed to Kratie combined with intervening flows (using the SSARR model[4]) to provide input data to the Delta model at Kratie. Finally, hydrographs of the natural and regulated flows for each mesh of the model were drawn on the same sheets of paper using an auxiliary plotting programme of the delta model package.

2 *Topography and Land Units*

In order to distinguish lands of different characteristics, the study area was divided into eight land units, with the water conditions in the flood season being the primary criterion for classification (Fig. 6). The eight land units, with names relating to their characteristic physiographic and hydrologic features, are as follows:

I. Tonle Sap floodplain;
II. Muk Kampul floodplain;
III. Tonle Toch terrace (Old Delta);
IV. Prey Veng floodplain;
V. Plain of Reeds (Cambodia);
VI. Kandal island;
VII. Takeo depression; and
VIII. Vaico lowland.[5]

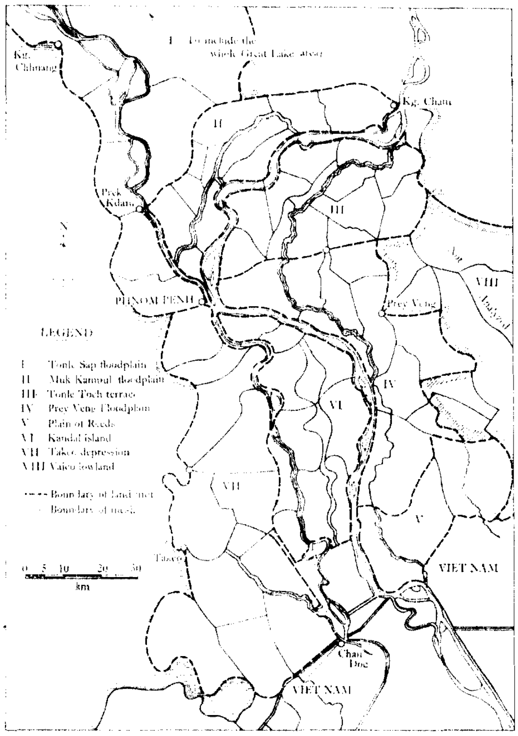


Fig. 6 Land Units in the Cambodian Part of the Mekong Delta

Note: Refer to Table 1 to locate the area shown in this figure in the whole Mekong delta. The rectangular area shown in the figure attached to Table 1 corresponds to this area.

4) The computer program designated by the title "Streamflow Synthesis and Reservoir Regulation," abbreviated "SSARR" was developed by the North Pacific Division, Corps of Engineers, USA, and was readapted to the Mekong basin for use in the Mekong Secretariat for simulation of the Mekong river flow under various circumstances.

5) Hydrologic analysis was omitted for this land unit because of substantial errors involved in the computer outputs for this particular region.

These land units will be considered in the subsequent discussion as the basic units for describing macroscopic characteristics of the regimes. That is, the water conditions in a particular land unit will be assumed to be essentially homogeneous on a macro-scale. However, in a land unit and even in a single mesh, neither topography nor water conditions are truly homogeneous, whereas the mathematical model assumes that the water surface level within a mesh to be flat and level. The accuracy of analyzing local water conditions largely depends on the accuracy of micro-topographic analysis and the size and location of the mesh concerned. Thus a detailed 1/50,000 contour map was drawn using U.S. Army Map Service maps and SOGREAH's contour maps. This map and the mesh hydrographs were then used to classify land as high, medium, and low elevation lands in each mesh. This simple classification is used in Chapter IV to relate local water conditions to agricultural practices.

3 *Hydrograph Analysis*

From the hydrographs thus obtained for each mesh the following factors relating to water regimes and their possible effects on agriculture, were extracted for both cases (with and without Pa Mong):

Peak sustained water level;
Maximum drawdown of peak water level;
Increment flood-free areas as the result of reduction of peak water level;
Maximum depth of water (for high, medium, and low elevation lands in each mesh);
Maximum rate of rise of water level (ditto);
Duration of inundation (ditto);
Duration for which the peak water level is sustained.

These factors for each of the 81 selected field meshes in Cambodia were grouped according to the land units, so that their average values could be calculated for each land unit. The average values for each factor were plotted against the recurrence time intervals of the floods for the test years, for each of the alternative cases of Pa Mong. This will be described in the following chapter.

The methodology used in the interpretation of possible effects of change of water regime on agriculture will be discussed in Chapter IV.

III Results of Hydrologic Analysis

1 *Presentation of Data*

A very extensive table (not shown in this paper) was compiled to show all hydrologic factors for each mesh of the delta model, for each Pa Mong alternative case, and for the four test years. The hydrologic factors include the following items for lowland, medium-elevation land and highland in each mesh:

a. Maximum water depth in the high water season,
b. Duration of inundation (in days) during the season,
c. The rate of rise of the water level, and

d. Period during which the peak water level is sustained.

It was this mesh-based information that was actually used in the analysis of possible impacts of the changed water regime on Cambodian agriculture as will be described in chapter IV. However, for convenience of presentation, only a small selection of recompiled land-unit-based hydrologic information will be presented here, as and when necessary for explanation.

A typical hydrograph was selected from each land unit and is presented for reference in Appendix 1A and 1B for 1961 (high flood year) and for 1963 (medium flood year) for PM 2000 (the PM 2000 case). All the hydrologic data were regrouped according to land unit, and the average values for each land unit and for each Pa Mong alternative case were tabulated in Appendix 2A through 2D. Each hydrologic factor is plotted against the recurrence period of floods to be exceeded[6] for the corresponding test years for each land unit covering all of Pa Mong alternatives. An example for land unit I (Tonle Sap floodplain) is shown in Appendix 3.

2 *Interpretation of Present Hydrologic Regime in Land Units*

For purposes of presentation the study area was subdivided into four different subregions with respect to water regime, as follows:

(1) Upstream river floodplain, comprising the Muk Kampul floodplain and the Tonle Toch terrace;
(2) Upstream lowlands of the Tonle Sap floodplain and the Prey Veng floodplain;
(3) Kandal island-like floodplain;
(4) Depressed zones in the lower stream reaches comprising the Takeo depression and the Plain of Reeds (Cambodia).

In the first subregion, the water regime is almost violent as that in the mainstream river, being characterized by short periods of peak sustained water level (less than ten days), an extremely high rate of rise in water level (as high as 40 cm per day), very deep inundation in depressions (up to 5 m), and relatively short periods of inundation. This area can be said to be essentially the fringe part of the Mekong river, with stage hydrographs almost similar to those of the river.

By comparison, the regime of the second subregion is attenuated by the buffering effect of the Great Lake and of Prey Veng lake. The durations of peak sustained water levels are relatively short and the maximum water depth ranges up to 5 m but the rate of increase in depth is reduced considerably to 10–15 cm per day.

In the third subregion, high levees encircling the area result in very poor drainage. The duration of inundation is extremely long in the lowlands (as long as five months), and very long in medium elevation lands (about 3-4 months). This subregions is more or less isolated from the Mekong river with respect to hydrologic features at the beginning of the flood recession period. A large area of marshlands characterizes this subregion.

6) Probability of exceeding the magnitude of flood in terms of peak discharge. For the period of inundation, the total volume of flood (July 1 - October 31) was taken instead of the peak discharge.

In the fourth subregion the water regime is gentle, being characterized by prolonged periods of peak sustained water level, moderate depths of inundation (less than 3 m), moderate rates of rise in water level (less than 10 cm per day), and long to moderate periods of inundation. This zone is not a river floodplain, but a depressed zone in which the major source of water is rainfall and runoff from local small streams. Flood waters from the main stream probably constitute only a minor part of the water in this subregion.

3　*Effects of Pa Mong on Water Regimes*

The effects of Pa Mong on water regimes have been evaluated in three different aspects:

(a) Reduction of the flood water level;
(b) Modification of the rate of water level rise;
(c) Reduction of the period of inundation.

3–1　*Reduction of Flood Water Level*

Maximum reduction of flood water level (e.g. maximum draw-down) with Pa Mong is generally significant, although it varies widely depending on Pa Mong's alternative considered, on the magnitude of the flood, and on the locality. When the Pa Mong alternatives were considered with respect to their effectiveness in controlling floods, PM 2000 was most effective and then, 250 MFC, 240 MFC, and 250 P+F in decreasing order. However, in the high flood years (i.e. 10-year recurrence flood) the PM 2000 and 250 MFC achieve almost equivalent control, and 240 MFC and 250 P+F also have effect almost equivalent. Generally, with PM 2000 and 250 MFC the maximum reduction in the peak water level is similar to the natural range of water levels, i.e., the 2-year recurrence flood water level without Pa Mong equals the 10-year recurrence flood water level with Pa Mong. In other words, with PM 2000 or 250 MFC the 10-year recurrence natural flood can be reduced to the conditions represented by a natural 2-year recurrence flood. Whereas with 240 MFC or 250 P+F, medium high floods of 5-year recurrence can be reduced to conditions represented by a natural 2-year recurrence flood.

The maximum drawdown with 250 MFC, for example, ranges from 1.0 to 1.3 m in the upper reach land units (I, II, III), and from 0.7 to 1.0 m in the lower reach land units (IV, V, VI, VII). Thus the effect of Pa Mong is of great imporatnce with respect to the peak water level reduction in the cases of PM 2000 and 250 MPC. This also applies to the maximum water depths regardless of locality (land unit).

Two major changes will occur. Deeply flooded areas will be relieved from damaging inundation, and at the same time zones experiencing shallow flooding under present conditions will no longer be flooded. This implies that the present practices of rice growing in the higher elevation lands will need to be readapted to the new water conditions.

3–2　*Flow Modification*

Modification of streamflows are reflected in the hydrographs in two ways. Firstly, the slope of the curve indicates the rate of rise of water levels and, secondly, the shape of the "peak" of the curve shows the durations for which the peak water level is sustained.

The maximum rate of rise of water level was measured on the stage hydrograph for each of the meshes when the water depth was shallower than 1 m above the lowest elevation of low, medium, and high-elevation lands respectively, taking into account the fact that the young rice plant is very susceptible to drowning in the rapidly rising water.

The average rates of rise of water levels to each land unit with and without Pa Mong are summarized in Table 3 for the 5-year recurrence flood. The rate varies greatly according to the land unit, with higher rates observed in upper reach land units (II, III, IV, VI) and lower rates in lower reach land units (V,VII) and Tonle Sap (I). Thus

Table 3 Average Maximum Rate of Rise in Water Levels in Land Units With and Without Pa Mong

(1) Lowlands

Unit : cm/day

Land unit		Pa Mong alternatives				
		Natural	PM 2000	250 MFC	240 MFC	250 P+F
I	Tonle Sap floodplain	9.5	7.3	8.3	9.3	8.0
II	Muk Kampul floodplain	10.9	7.4	8.0	10.5	9.7
III	Tonle Toch terrace	23.5	22.5	19.6	25.5	18.8
IV	Prey Veng floodplain	12.7	8.9	9.0	13.3	9.2
V	Plain of Reeds (Cambodia)	9.5	7.8	7.1	8.8	7.5
VI	Kandal island	13.7	15.5	9.6	11.3	15.3
VII	Takeo depression	7.9	9.3	7.1	9.5	6.7

(2) Medium-elevation lands

Land unit		Natural	PM 2000	250 MFC	240 MFC	250 P+F
I	Tonle Sap floodplain	9.8	6.8	7.8	8.5	8.3
II	Muk Kampul floodplain	40.0	32.5	32.5	38.5	36.0
III	Tonle Toch terrace	25.5	19.0	21.5	24.6	23.3
IV	Prey Veng floodplain	22.7	15.7	17.3	21.3	19.5
V	Plain of Reeds (Cambodia)	12.0	4.2	5.3	8.7	8.6
VI	Kandal island	21.5	17.5	19.3	20.3	27.7
VII	Takeo depression	9.5	7.6	7.2	8.6	8.3

the reduction of the rate is more clearly observed in the present Mekong's floodplains than other parts more or less distant from the present river course. Generally, the rate is lower in lowland than in medium elevation land. The reason is that the lowland areas are filled more with local runoff waters than Mekong water in the early rainy season, whereas the water on the medium-elevation land comes from Mekong floods of peak stage during the later periods of the rainy season through numerous outlets of tributaries ("Prek" in Cambodian) as well as from the heavier rainfall of September. Thus in the lowland areas the reduction in the rate due to control at Pa Mong is less pronounced with slight reduction in the cases of PM 2000 and 250 MFC. In medium-elevation land the reduction in the rate is more pronounced than in the lowlands, but only PM 2000 and 250 MFC may have significant effects.

In general, in the area where the water regime is already gentle enough for sustaining floating or late maturing rice growing, the water regime becomes much more favourable with Pa Mong. However, in those areas where the water regime is already too violent and the flows too great for any agricultural activities, the water conditions will remain almost as unfavourable as without Pa Mong, regardless of any reduction in the rate of water rise which may be observed.

3–3 *Reduction of Period of Inundation*

In most parts of the lowlands and medium-elevation lands the controlled Mekong floods will come from one to two weeks later and recede from one to two weeks earlier. Consequently the period of inundation is shortened by approximately from two to four weeks. In most of the highlands, where the period is already short, inundation will cease.

3–4 *Summary of Effects*

The overall effects of Pa Mong on the water regime are substantial. The order of importance of the individual factors may be listed as follows:

(a) Flood level reduction;

(b) Reduced period of inundation;

(c) Reduced rate of rise of water levels.

The order of overall capability of controlling floods is PM 2000, 250 MFC, 240 MFC, and 250 P+F in decreasing order. PM 2000 and 250 MFC have almost equivalent effects, and 240 MFC and 250 P+F also have almost equivalent capability for control. However, the difference in the capability between the former and the latter group is significant. With the latter group the effects could better be termed flood relief rather than flood control. However, since the flood lands are so flat, even limited flood relief would have an important impact on agriculture.

IV Impacts on Agriculture

Agriculture in the Cambodian floodplain will be subject to considerable readjustment following the construction of the Pa Mong dam. Some foreseeable changes are:

(1) Extension of the cultivable areas towards the lowlands (possible extension of floating rice area);

(2) Decrease of occasional flood damage to ordinary rice in low-to-medium elevation lands and even in the highlands;

(3) Change of rice varieties and cultural practices in flood-relieved areas;

(4) Possible extension of the drought-susceptible areas in the highlands which will no longer be reached by flooding;

(5) Extension and improvement of dry-foot crop cultivation on "chamkar" lands;

(6) Modifications in chamkar agriculture due to possible reduction of silt deposition; and

(7) Possible change in the dry season rice cultivation.

Items (1), (2) and (3) above are dealt with in this chapter. Items (5) and (6) will be discussed in a separate paper to follow.

1 *Present Land Use*

The major crop grown in the study area is rice, which covers highlands, medium-elevation lands, and parts of lowlands except on levees and the upper part of chamkar lands. The levees and chamkars are used for dry-foot crops.

Table 4 Environmental Conditions Governing Rice Cultivation

Varieties	Water conditions		Topography (altitude)	Soils
	Water depth	Period of inundation		
Early maturing	Intermittent submersion	Very short	Terrace (high)	Coarse grained
Semi-seasonal	Shallow	Fairly short	Terrace and Floodplain	Fairly coarse
Seasonal	Shallow-medium	Medium	Floodplain (medium altitude)	Medium
Late maturing	Medium-deep	Medium-long	Floodplain (low)	Fine
Floating	Very deep	Long-very long	Floodplain (low)	Fine
Dry season	Dry season irrigation available	Irrigation	Floodplain (low)	Fine

Source: Modified from Kato, Y., "Rice and Field Crops in Cambodia," 1966. (Ref. 12)

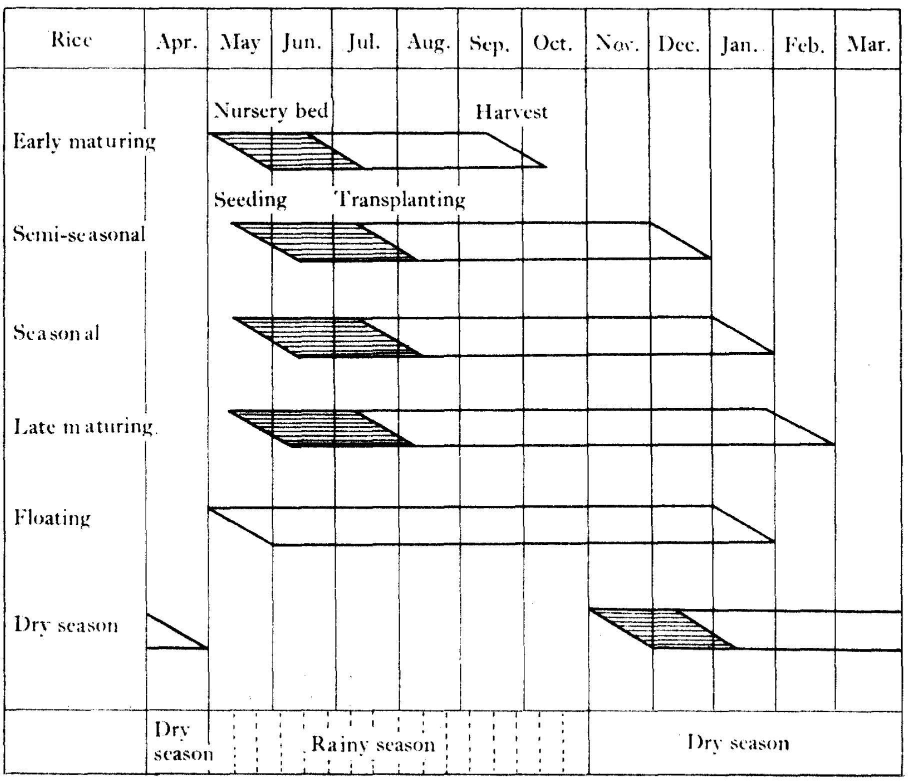


Fig. 7 Growing Seasons of Rice in Cambodia (Ref. 12)

Rice varieties and cultural practices have carefully been adapted over hundreds of years to the natural environmental conditions in the Cambodian delta, especially the water regime. The present rice culture shows an excellent level of adaptation considering the very unstable water conditions.

Rice varieties grown in the region can be correlated with environmental conditions as summarized in Table 4 (Ref.12).

The growing seasons of different rice varieties are illustreated in Fig. 7 (Ref.12).

2 *Preliminary Analysis of Present Crop Failure from Flood and Drought*

The rice culture of Cambodian floodlands relies on natural environmental conditions and is at the mercy of erratic annual cycles (Ref.13,14). Production fluctuates considerably from one year to another. Primary causes of the crop damage are flood in the low to medium-elevation parts of the lowlands, drought in the medium-high parts of the lowlands and in all terrace areas, plus the effects of pests and diseases.

Because the periods of the time-series data available on crop damage are rather short for statistical analysis, an attempt was made to obtain qualitative correlation between rice production[7] and some characteristics of the water conditions, e.g., maximum water levels of the Mekong or the Great Lake, or of the corresponding land units,[8] e.g., the rate of rise of water levels in the land units, and seasonal rainfall. The maximum water levels and the rate of rise of water levels of the Mekong or the Great Lake, or in the corresponding land units were obtained from data given in the earlier chapters, since each year's flood recurrence period measured at Phnom Penh or at Kratie was known.

Correlations between the production and the water regime are shown for the Takeo depression, Battambang province, Kandal island, and Prey Veng floodplain, in Appendix 4A and 4B. The relationship between production in the Great Lake provinces (Siem Reap, Battambang, Pursat, Kg. Chhnang, and Kg. Thom) and the Great Lake water level is given in Fig. 8.

Some approximate relationships appear to exist between the maximum water level in each land unit and production. Although no definite correlative function can be found, there definitely exists an optimal water level for the harvest. This appears to be 7.0–8.0 m in the Prey Veng floodplain, 5.0 m in the Takeo depression, 8.5–9.5 m in Kandal island, 8.5–9.0 m in Battambang province, and 9.0–9.5 m in the Great Lake provinces. Deviating from these optimal levels, the production drops very sharply. In the areas analyzed, the reduction of production in the cases of low water levels (possibly drought) is more drastic and extreme than for the high water level cases (possibly flood),

7) Total production in a province, not the yield per unit area, is considered here because data on planted areas, harvested areas, and damaged areas are not available; also, the reliability of these data is questionable. Only the production data after 1955 (in one case after 1950) were analyzed, hence the effects of increased production from extended cultivated areas are less pronounced in the analysis.

8) Note that the geographical boundaries of the provinces for which the production statistics are based, and the boundaries of the land units which are the basis for the water regimes analyzed, do not coincide. Thus it is rather difficult to extract the probable effect of Mekong water on the rice production based on use of provincial statistics, instead of statistical data on district (srok) basis. Despite these difficulties some useful correlations were made.

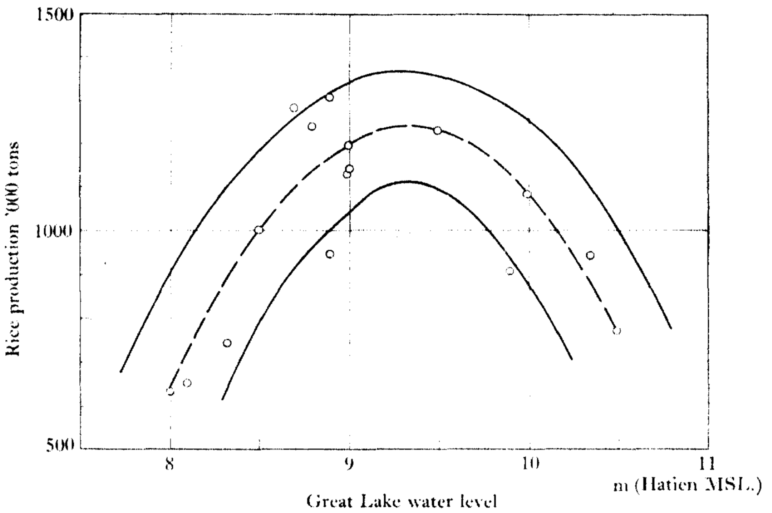


Fig. 8 Rice Production as Related to Great Lake Water Levels in the Great Lake Provinces
Data source: Ref. 13 and 15.

although the damage caused by the latter may be total failure of the crop in certain areas.

A functional relation exists between production and the rate of rise in water level in Kandal island, and also, but less clearly, in the Takeo depression. The general indication is that a slower rate is more favourable for crop production in high flood years. In other land units no relationship could be found, partly because the large acreages of rice land included terraces and small tributary basins not accessible directly to Mekong waters.

Fairly good correlations were obtained between production and total monsoon rainfall (May-October). An interesting point is that there exists an optimal amount of rainfall of 1,200–1,300 mm regardless of the land units analyzed. Too much rainfall seems to limit good harvests even in these drier zones of continental Southeast Asia. This may be due to harvest losses caused by localized flooding of depressions and small tributary basins following short duration, high intensity monsoon rains during September and October.

The Battambang data indicates that early wet season rainfall (May-July) influences production. Less than 400 mm of rainfall during the period reduces production by limiting transplanting while too much rain (especially storms) may reduce production by drowning newly transplanted seedlings.

3 *Extension of Cultivable Areas towards the Lowlands, and Change of Rice Varieties and Cultural Practices*

3–1 *Criteria for Floating and Late Maturing Rice Production*

Following an analysis of the water conditions in the floating and late maturing rice areas, criteria were established as shown in Table 5.

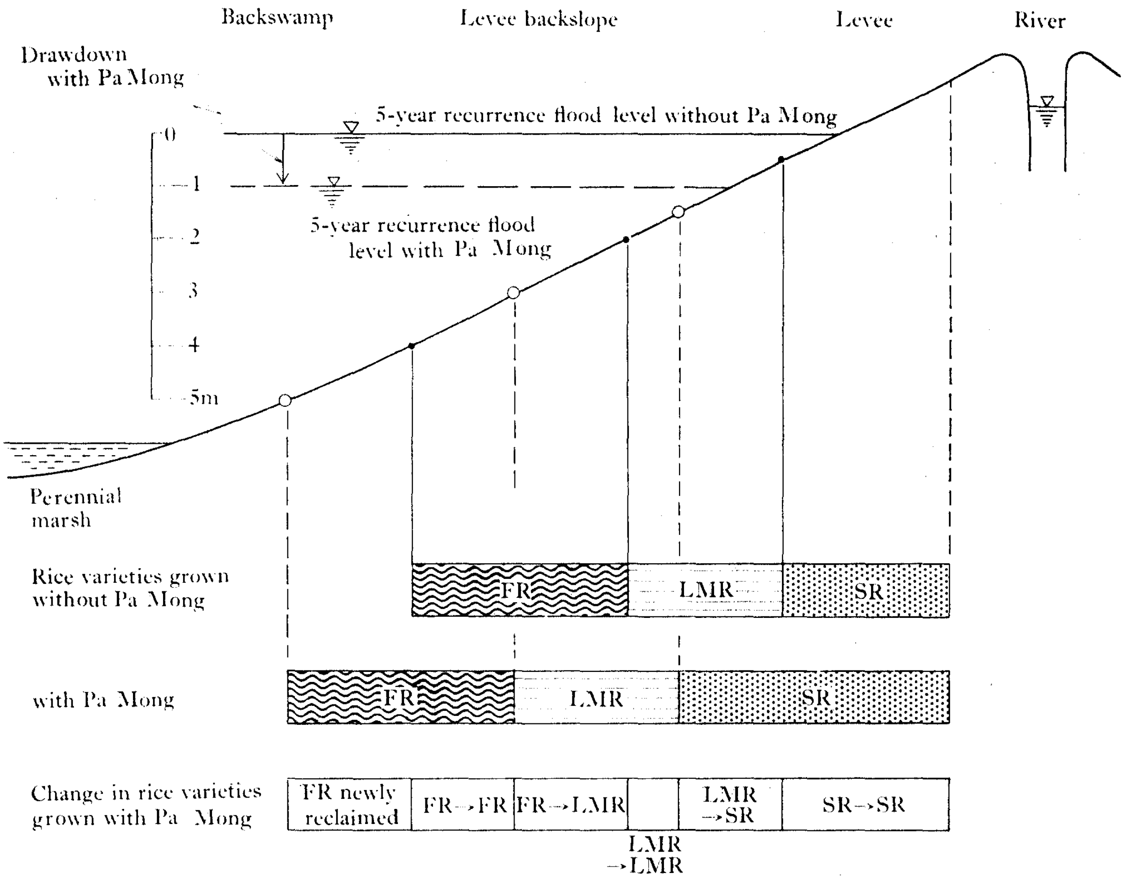
It is postulated that a farmer adjusts his area of floating and late maturing rice to a high water condition expected to recur once in five years. That means he will be satis-

Table 5　Criteria for Floating and Late Maturing Rice Production

Factor	Floating rice	Late maturing rice
Water depth	2:-4m	0.5-2m
Period of inundation	More than 90 days	More than 30 days
Rate of rise of water level		
Young plant	Less than 10 cm/day	Less than 10 cm/day
Established plant	Less than 15 cm/day	Less than 10 cm/day
Duration of peak sustained water level	More than 10 days	More than 10 days

fied if he can harvest a good crop four out of five years, and will tolerate damage to his rice harvest once in five years.

A postulated rice cropping pattern, along a typical cross section of levee backslope and backswamp, is shown schematically in Fig. 9. Under this assumption, almost the same rice cropping patterns as without Pa Mong will be retained; they are simply shifted and extended towards the lowlands.



FR: Floating rice　LMR: Late maturing rice　SR: Seasonal rice

Fig. 9　Possible Changes in Rice Cropping Patterns along a Typical Levee Backslope with Flood Control

Note: Similar model as shown here can be applied to other landscape like Great Lake area and the peripheral areas of the Cambodian lowland.

3–2 *Procedure*

The principal steps in the estimation of rice crop areas are as follows:

(a) Determine the possibility of growing floating and late maturing rice for each mesh according to the criteria for natural water regime;

(b) Compute the gross area of rice following the procedure shown in Fig. 9 for each mesh;

(c) Find correction factors for converting the gross area to net area for each province by comparing the estimated values with provincial statistics;

(d) Repeat the procedure (a) and (b) for water conditions regulated by each of the Pa Mong alternatives;

(e) Apply the same correction factors determined for natural conditions to the conditions as altered by Pa Mong;

(f) For seasonal and semi-seasonal rice, determine the crop area by land units.

The correction factors for converting the gross estimated areas to net rice areas were determined as follows:[9]

Province	Correction factors	
	Floating rice	Late maturing rice
Great Lake areas	0.89	0.74
Kandal	0.81	0.74
Kg. Cham	0.70	0.80
Prey Veng	0.79	0.80
Takeo	0.69	0.85

3–3 *Results and Discussion*

Extensive computation was carried out to determine the net areas for each mesh and for each of Pa Mong alternatives designated as "Extended FR" (floating rice area extended in the meshes where floating rice was grown before), "New FR" (floating rice area in the meshes where no rice was grown before), "FR→FR" (floating rice area with and without Pa Mong), "FR→LMR" (late maturing rice area in the meshes where floating rice was grown before), and "LMR→LMR" (late maturing rice area with and without Pa Mong). (See Fig. 9)

The above information was then recompiled to show the total areas by land units (Appendix 5).

The areas for seasonal rice were computed by land units for each Pa Mong possible case, and these data are presented in Appendix 6.

9) The computed rice areas under present water conditions correspond well with the actual areas of production under the assumptions previously stated. The correction factors for floating and late maturing rice areas fall within a very reasonable range. Thus the same correction factors (applied to each province) will be used for the with-project conditions.
The correction factors for seasonal and semi-seasonal rice could not be determined as the planted area of the seasonal rice is far larger than the study area for each province.

The total net rice areas for the above three varieties are shown in Fig. 10 for easy comparison for the alternative cases.

The "new floating rice area" has not expanded much in terms of the number of meshes, but has expanded with respect to area. Even with Pa Mong, floating rice will be grown almost in the same meshes as without Pa Mong. The determining factor limiting the possible extension of the floating rice area is the high rate of rise in water level. Thus, floating rice can probably never be grown, even with Pa Mong, in large parts of the Muk Kampul floodplain, the Tonle Toch terrace (Old Delta), and the Kandal island, whichever Pa Mong dam was built.

The most promising regions in the study area with respect to possible extension of new farmland towards the lowlands are the Tonle Sap floodplain (especially the Great Lake area) and the Takeo depression, followed by part of the Prey Veng floodplain and the Plain of Reeds (in Cambodia), which are now major areas of wet season rice production.

Regarding the area of "new rice area" with Pa Mong, the effects of all of the four possible projects are substantial. Newly reclaimed areas (Extended FR plus New FR) amount to ca. 2,210 km^2 for PM 2000, ca. 2,150 km^2 for 250 MFC, ca. 1,490 km^2 for 240 MFC, and ca. 1,320 km^2 for 250 P+F. Note here that the areas made available for rice production with PM 2000 and 250 MFC are almost equivalent, and with 240 MFC and 250 P+F are also nearly equivalent. Also, the difference between the former and the latter group is significant. The extent of the areas which may be reclaimed appears to be approximately proportional to the capability for controlling the water regimes shown by the possible Pa Mong schemes.

Moreover substantial changes in rice varietal constituents take place in the present rice area as shown in Fig. 10. With PM 2000 and 250 MFC, more than half of the present floating rice area would be converted to late maturing rice, and almost all of the present late maturing rice area to seasonal rice. With 240 MFC and 250 P+F this conversion would be less significant, but still substantial. This would be a major benefit of Pa Mong because ordinary rice (LMR and SR in lower altitude) has a higher yielding potential and is of better quality under the proper management evnisaged in furture. It is noted that this conversion could take place simultaneously with the project implementation, with almost no additional cost. By comparison, the extension of new farmlands towards lowlands would proceed over a period of many years, its speed depending on various factors related to the socio-economic conditions of the country. However, there would be no technological constraints to expansion, and the additional cost involved will be very small.

The immediate and future gains from the increased production of rice were estimated in terms of tonnage as shown in Table 6. In this estimation the average paddy yields of three major varieties are assumed to be the same as the respective averages for the entire country under the present condition of water and cultural practices, as follows:

Floating rice　1.7 ton/ha
Late maturing rice　1.9 ton/ha

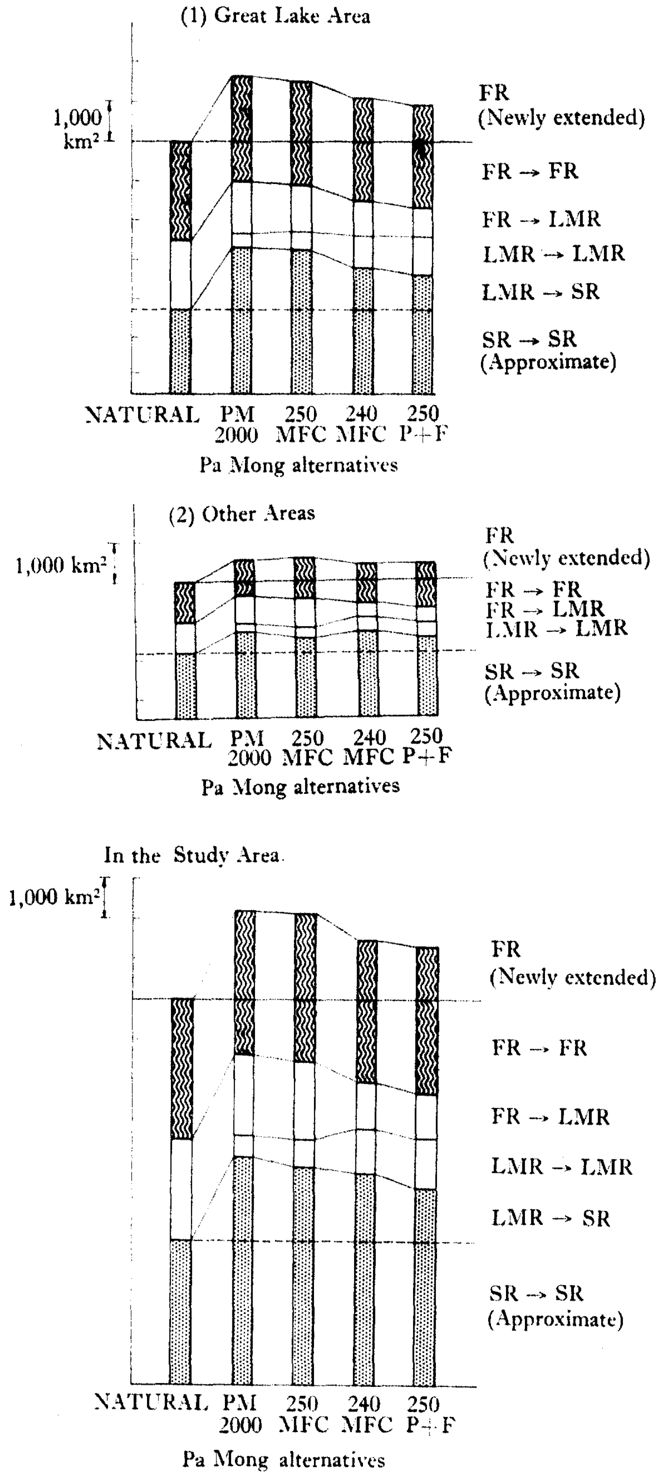


Fig. 10 Rice Areas by Variety With and Without Pa Mong

Note: Approximate rice areas as of 1975 are 9,700 km² in the study area, of which 6,400 km² in the Great Lake area and the rest 3,300 km² in the rest of the study area.

Seasonal rice[10] 1.9 ton/ha

The immediate gain from the increased rice production owing to the varietal changes is 50,000; 49,000; 49,000; and 37,000 tons/year for PM 2000, 250 MFC, 240 MFC, and 250 P+F, respectively. The future gain from the extended rice lands is 375,000; 365,000; 253,000; and 224,000 tons/year respectively for the possible projects. The total gain from the above two categories is 425,000; 414,000; 302,000; and 261,000 tons/year respectively.

Note here that the gain that results from the Great Lake area (the Tonle Sap floodplain) accounts for about 70 per cent of the total gain from the entire country as shown in Table 6 and Fig. 10.

4 *Relief from Flood Damage*

Possible flood damage to transplanted rice grown in medium-high elevation lands was analyzed based on the mesh according to the following criteria;

(1) Relatively young rice crop will be damaged when water depth exceeds 50–100 cm over seven consecutive days;

(2) Established rice crop will be damaged when water depth exceeds 100 cm over seven consecutive days.

10) Although average yield of seasonal rice (including seasonal, semi-seasonal, and early maturing rice) is somewhat lower than 1.9 ton/ha, the yield of seasonal rice in the area concerned is assumed to be the same as late maturing rice in view of the very favourable conditions of soil and water expected in the area.

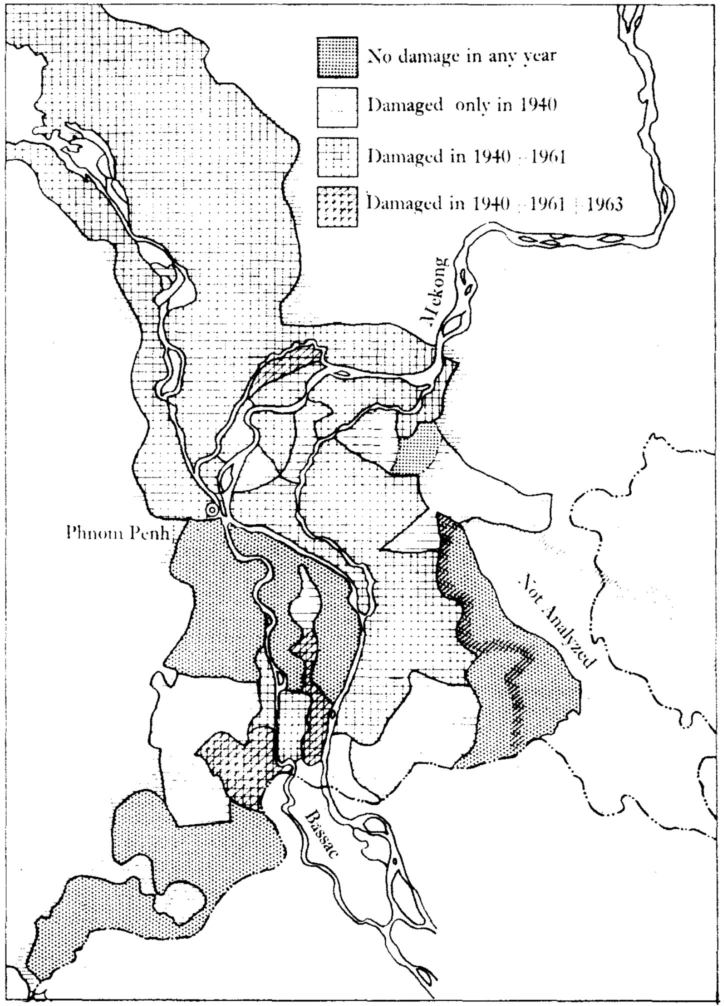


Fig. 11A Flood Damage to Rice Crop in Medium Elevation-Highlands without Pa Mong

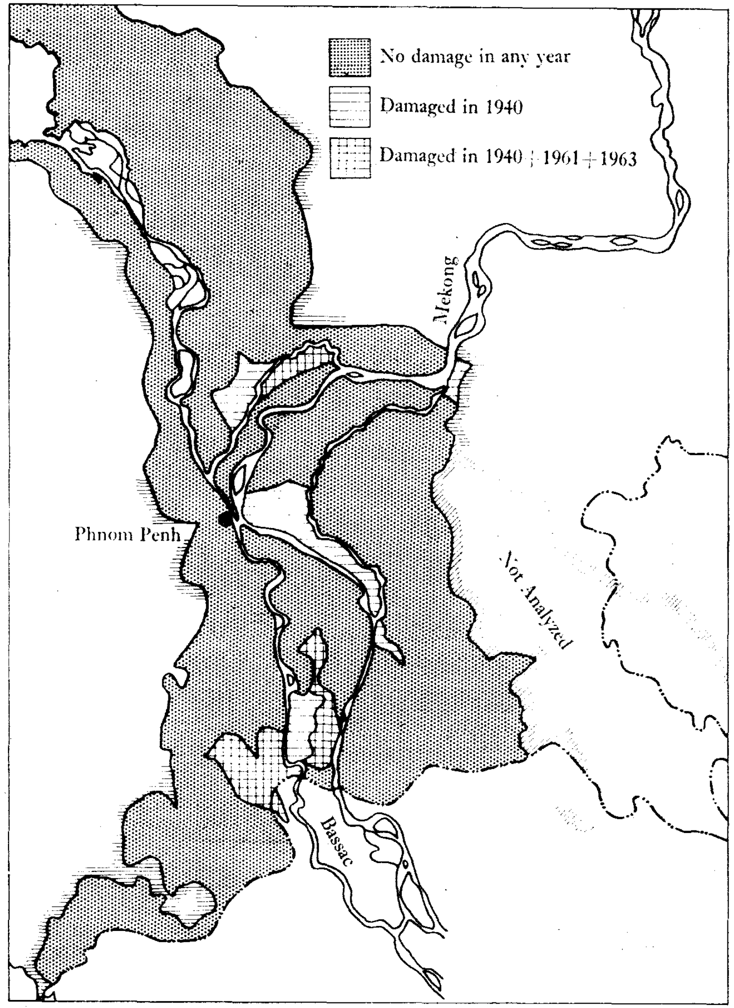


Fig. 11B Relief from Flood Damage to Rice Crop with Pa Mong (PM 2000)

Table 6 Increased Rice Production with Pa Mong

Unit : 1,000 ton/year

Type of benefit	Region	Pa Mong alternatives			
		PM2000	250MFC	240MFC	250P+F
Immediate gain	Great Lake area	33	36	32	21
	Other areas	17	13	17	16
	Sub-total	50	49	49	37
Ultimate gain	Great Lake area	280	251	183	155
	Other areas	95	114	70	69
	Sub-total	375	365	253	224
Total	Great Lake area	313	287	215	176
	Other areas	112	127	87	85
	Grand-total	425	414	302	261

The results, before and after Pa Mong, are illustrated in Fig. 11A and 11B respectively for PM 2000. With PM 2000 and 250 MFC virtually none of the areas in medium-high elevation lands (where seasonal and semi-seasonal rice are grown) would be subject to further flood damage. The contrast of flood-damage in medium-high elevation lands before and after Pa Mong is striking. Although the computations for 240 MFC and 250 P+F have not been made, it may be safe to say that with these cases at least the highlands would no longer experience damaging floods judging from the hydrological regimes analyzed in the earlier chapters.

However, in lowlands which now include the old floating rice and newly reclaimed rice areas with project, damaging floods will recur almost as frequently as before, because it is presupposed the new cropping pattern with project will be subjected to the altered water conditions in the same way as the present rice is to the present water conditions. That means the water conditions in lowlands with project (especially in newly reclaimed areas) will be as severe as before. It should be noted again that Pa Mong can reduce the flood water levels substantially, but it can not regulate other hydrologic characteristics such as large year-to-year fluctuation (this is the same or larger than the draw-down range with project), high rate of rise in water level, etc., to any substantial extent.

References

1) "Pa Mong Downstream Effects on Hydrology and Agriculture in Democratic Kampuchea." *Working Paper 6, Pa Mong Optimization and Downstream Effects Study,* Mekong Committee publication MKG/41, 1976.

2) "Mekong River." in *A Compendium of Major International Rivers in the ECAFE Region,* Water Resources Series, No. 29, United Nations, 1966.

3) "*Pa Mong Optimization and Downstream Effects Study, Main Report(draft); Volume 1 Text.*" Mekong Committee publication MKG/45, 1977.

4) "Report of the Second Meeting of the Ad Hoc Working Group on the Declaration of Principles for Utilization of the Waters of the Lower Mekong Basin." Note by the Mekong Secretariat MKG/R. 126, 1975.

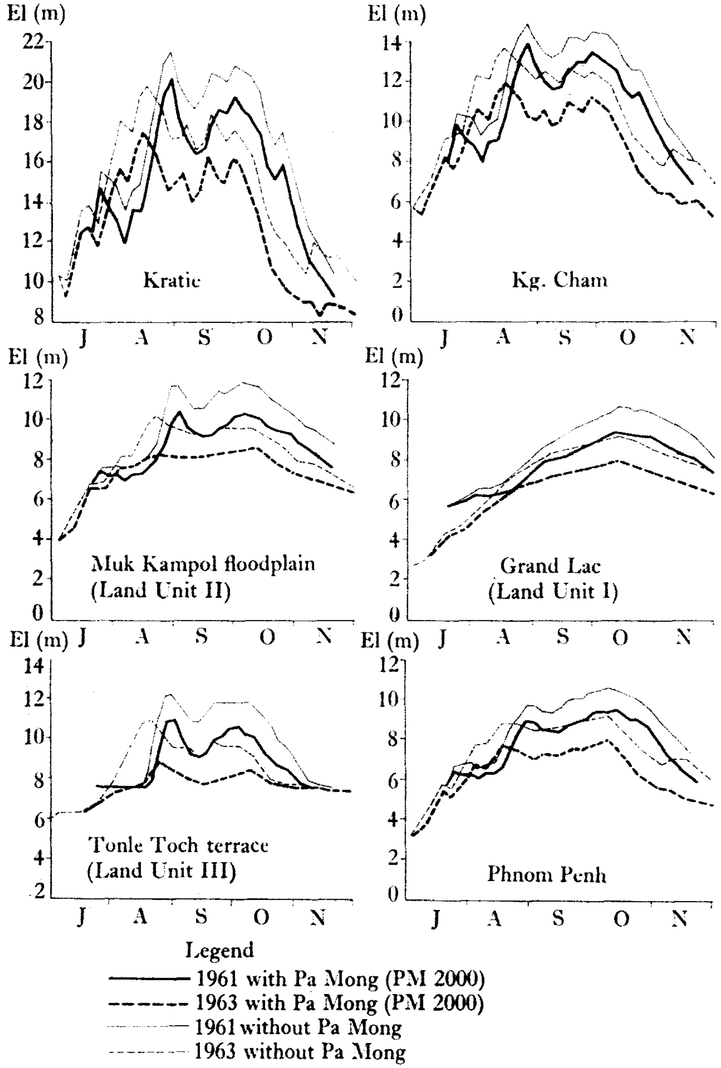
5) "General Soil Map, Kingdom of Cambodia." Ministry of Agriculture, Phnom Penh, 1963.

6) "Flood Regulation Studies." *Working Paper 3, Pa Mong Optimization and Downstream Effects Study,* Mekong Committee publication MKG/38, 1976.
7) "Analysis of Hydraulic Relationship of Flood Water Levels and Approximate Flooded Areas in the Mekong Delta for the 1961 Flood." Mekong Secretariat, 1974.
8) "*Mathematical Model of Mekong Dalta, Vol. III-1.*" Prepared by SOGREAH for the Mekong Committee, 1964.
9) "*Modèle Mathematique du Delta du Mékong, III-1, III-2, III-3* (*Compagne de Mesures*)." Prepared by SOGREAH for the Mekong Committee, 1966.
10) "*Mathematical Model of Mekong Delta, Vol. IV-2 Adjustment of the Final Model.*" Prepared by SOGREAH for the Mekong Committee, 1966.
11) "*Étude du Delta du Mékong sur Modèle.*" Unesco/PNUD, Elément Fonds spécial, No. série du rapport: 9, 1970.
12) "Rice and Field Crops in Cambodia." by Y. Kato, published in *Water Resource Utilization in Southeast Asia,* CSEAS of Kyoto University, 1966.
13) "*Rapport Annuel, L'agriculture Cambodgienne en 1969-1970.*" Royaume du Cambodge, Direction de l'agriculture, Phnom Penh, 1972.
14) "Impact of Rain and Flood on Paddy Production." Working Paper 1, *Recommendation Concerning Agricultural Development with Improved Water Control in the Mekong Delta.* Prepared by the Netherlands Delta Develoment Study Team for the Mekong Committee, 1974.
15) (a) "*Dégâts Causes par les Crues et Sécheresse à la Riziculture par Province* (*1966-67 a 1973-74*)."
(b) "*Dégâts à la Riziculture par inondation par Srok Disponibles des 4 Provinces de Battambang, Kandal, Siemreap et Kg. Chhnang.*" Direction de l'Agriculture, République Khmère, 1975
16) "*Nippon no Mizushigen.*" (in Japanese). by H. Takahashi, The University of Tokyo Press, 1963.

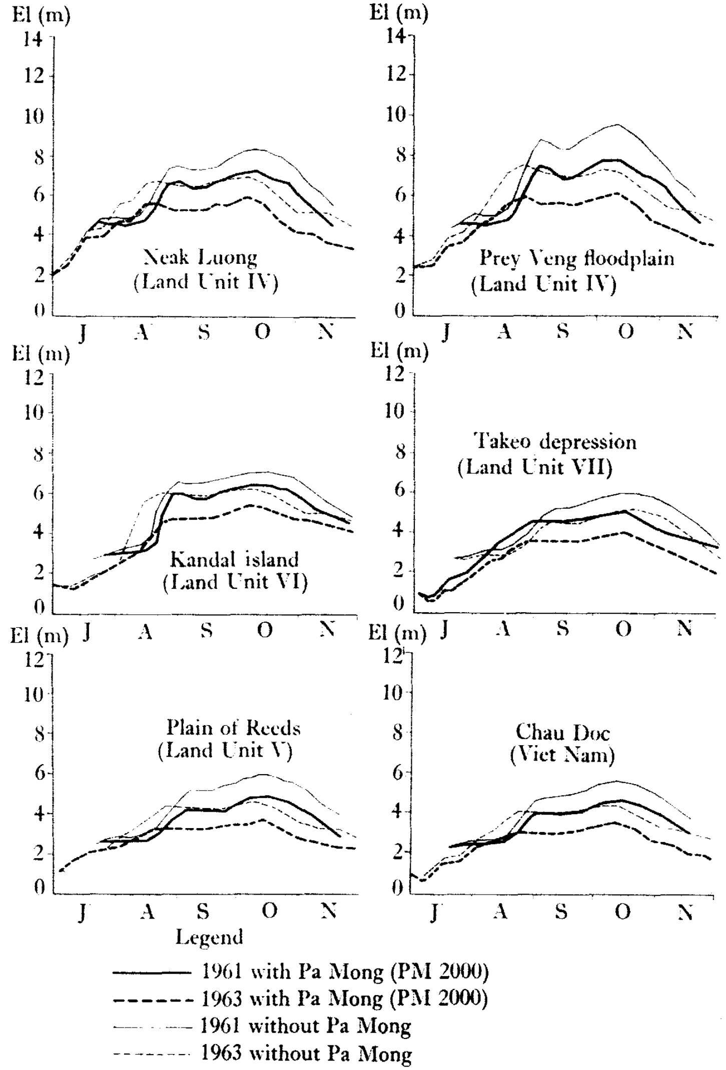
Appendix 6 Net Seasonal and Semi-Seasonal Rice Areas With and Without Pa Mong

Unit : km²

Land unit		Pa Mong alternative cases				
		NATURAL	PM 2000	250 MFC	240 MFC	250 P+F
I	Tonle Sap floodplain	2,047	3,282	3,152	2,892	2,762
II	Muk Kampul floodplain	75	140	130	107	107
III	Tonle Toch terrace (Old delta)	416	585	559	510	510
IV	Prey Veng floodplain	185	432	403	305	305
V	Plain of Reeds	20	83	77	52	52
VI	Kandal island	221	345	328	289	276
VII	Takeo depression	702	949	910	838	819
Total	Area	3,666	5,816	5,559	4,993	4,831
	Ratio	100	160	150	140	130



Appendix 1A Typical Hydrographs from Each Land Unit



Appendix 1B Typical Hydrographs from Each Land Unit

Appendix 2A Average Hydrologic Values With and Without Pa Mong (PH 2000)

Land Unit	Total area of land unit	Year analyzed	Peak sustained water level		Max. Draw-down of W.L.	Area free from inundation by Pa Mong	Max. Water depth						Max. Rate of rising water level						Duration of inundation						Period of keeping peak sustained W.L.	
							Lowland		Medium		Highland		Lowland		Medium		Highland		Lowland		Medium		Highland			
							Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM		
	(km²)		(m)		(m)	(km²)	(m)		(m)		(m)		(cm/day)		(cm/day)		(cm/day)		(days)		(days)		(days)		(days)	
I.	17,690	1957	8.7	8.1	0.6	12,040	3.2	2.6	1.3	0.7	0	0	12.0	11.2	8.0	5.6	0	0	148	125	73	45	0	0	13	10
Tonle Sap	(14,690)*	1963	9.2	8.0	1.2	12,030	3.7	2.5	1.8	0.6	0	0	13.0	7.7	7.2	3.6	0	0	143	144	96	39	-	0	10	8
floodplain		1961	10.6	9.4	1.2	14,060	5.1	3.9	3.2	2.0	1.3	0.2	7.7	7.0	11.0	8.3	5.4	4.9	>	>	107	88	65	13	10	16
		1940	10.7	9.7	1.0	15,010	5.1	4.2	3.3	2.3	1.4	0.4	9.6	7.1	10.0	9.3	8.0	5.8	144	>	90	84	60	26	13	11
II.	1,180	1957	10.1	9.4	0.7	815	3.9	3.2	1.6	0.9	-	-	17.5	13.0	22.3	18.0	-	-	135	156	67	46	-	-	4	4
Muk Kampul		1963	10.7	9.0	1.7	785	4.5	2.8	2.2	0.5	-	-	21.9	9.4	34.4	8.5	8.1	-	141	-	86	40	7	-	4	7
floodplain		1961	12.2	10.9	1.3	920	6.0	4.7	3.7	2.5	1.5	0.3	5.6	6.4	42.5	44.0	22.5	13.1	148	149	100	77	61	6	7	5
		1940	12.7	11.7	1.0	960	6.5	5.4	4.2	3.2	2.0	0.9	8.7	5.8	23.8	29.4	20.4	13.4	138	149	95	69	49	23	5	4
III.	1,480	1957	9.7	9.3	0.4	540	2.4	2.0	0.8	0.6	-	-	24.4	17.8	13.9	9.8	-	-	106	104	30	15	-	-	4	3
Tonle Toch		1963	10.2	8.9	1.3	460	2.9	1.5	1.3	0.3	0.1	-	32.4	15.6	18.1	8.6	-	-	114	100	53	17	2	-	5	11
terrace		1961	11.5	10.2	1.3	720	4.2	3.0	2.5	1.4	0.9	0.1	19.3	26.0	29.0	24.4	16.6	5.7	128	130	79	46	51	2	6	4
		1940	12.1	11.0	1.1	910	4.8	3.7	3.2	2.1	1.5	0.5	11.1	14.0	17.0	15.2	13.0	6.2	122	78	70	50	43	16	5	5
IV.	1,730	1957	6.9	6.4	0.5	1,140	2.5	2.0	0.8	0.3	-	-	13.1	13.1	13.3	10.2	-	-	132	119	48	18	-	-	6	5
Prey Veng		1963	7.4	6.1	1.3	1,070	3.0	1.7	1.3	0.2	-	-	18.1	9.7	15.8	8.7	-	-	131	113	69	14	1	-	5	8
floodplain		1961	9.3	7.6	1.7	1,425	4.9	3.2	3.2	1.5	1.4	0.4	10.2	8.6	26.2	19.0	17.7	5.6	140	147	86	63	62	4	8	8
		1940	9.9	8.6	1.3	1,640	5.5	4.2	3.8	2.5	2.0	0.8	7.9	8.0	18.6	14.8	10.9	8.8	129	137	80	56	52	23	6	6
V.	850	1957	4.3	3.7	0.6	375	1.6	1.09	0.3	-	-	-	10.8	7.1	5.7	2.5	-	-	113	86	51	-	-	-	8	11
Plain of		1963	4.7	3.7	1.0	375	2.0	1.0	0.7	-	-	-	8.1	7.1	6.5	2.5	-	-	117	95	70	-	-	-	10	18
Reeds		1961	6.1	4.9	1.2	535	3.4	2.2	2.1	0.9	0.9	-	12.0	8.1	12.0	5.0	3.4	0.8	146	125	86	64	54	-	9	14
		1940	6.5	5.5	1.0	555	3.8	2.8	2.5	1.5	1.2	0.2	5.4	6.3	10.2	8.0	6.8	4.7	129	111	77	51	48	15	8	11
VI.	1,330	1957	5.9	5.4	0.5	770	2.6	2.2	1.2	0.8	0.2	-	15.8	14.1	15.7	15.2	2.5	9.0	92	135	80	69	17	3	12	11
Kandal		1963	6.2	5.3	0.9	750	3.0	2.0	1.6	0.6	0.3	0.03	19.9	15.2	18.0	5.9	2.4	1.2	129	141	104	59	23	2	17	18
island		1961	7.2	6.4	0.8	995	3.9	3.1	2.4	1.7	1.2	0.4	10.9	15.8	23.2	23.2	6.1	5.7	148	150	106	87	75	28	12	17
		1940	7.3	6.7	0.6	1,060	4.1	3.4	2.7	2.1	1.3	0.7	10.9	8.2	13.2	15.0	6.3	5.7	124	150	99	85	63	36	13	19
VII.	2,720	1957	4.8	4.4	0.4	1,220	2.2	1.8	0.9	0.5	0.1	-	10.9	11.8	8.9	6.9	0.1	0.2	105	111	69	42	7	2	12	13
Takeo		1963	5.1	4.3	0.8	1,160	2.5	1.6	1.2	0.4	0.1	-	10.6	9.2	7.4	4.6	0.7	0.6	138	109	93	38	9	-	20	30
depression		1961	6.1	5.3	0.8	1,640	3.4	2.6	2.1	1.4	0.8	-	6.7	9.4	10.6	9.0	5.0	3.0	>	145	111	84	56	6	15	26
		1940	6.2	5.6	0.6	1,740	3.6	3.0	2.3	1.7	1.0	0.2	9.9	6.3	7.8	7.2	5.3	4.7	141	>	96	76	56	21	13	19

Nat. : Natural ; PM : With Pa Mong ; – : No inundation ; > : Over 150 days

* Great Lake water surface area is excluded.

Appendix 2B Average Hydrologic Values With and Without Pa Mong (250 MFC)

Land Unit	Total area of land unit (km²)	Year analyzed	Peak sustained water level (m)		Max. Draw-down of W.L. (m)	Area free from inundation by Pa Mong (km²)	Max. Water depth						Max. Rate of rising water level						Duration of inundation						Period of keeping peak sustained W.L. (days)	
							Lowland (m)		Medium (m)		Highland (m)		Lowland (cm/day)		Medium (cm/day)		Highland (cm/day)		Lowland (days)		Medium (days)		Highland (days)			
							Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM		
I. Tonle Sap floodplain	17,690 (14,690)*	1957	8.7	8.1	0.6	12,040	3.2	2.6	1.3	0.7	-	-	12.0	10.3	8.0	5.7	-	-	148	132	73	50	-	-	13	12
		1963	9.2	8.1	1.1	12,040	3.7	2.6	1.8	0.7	-	-	13.0	9.7	7.2	5.0	-	-	143	125	96	64	-	-	10	4
		1961	10.6	9.5	1.1	14,070	5.1	4.0	3.2	2.1	1.3	0.2	7.7	7.4	11.0	9.1	5.4	4.1	>	>	107	95	65	26	10	16
		1940	10.7	9.8	0.9	15,030	5.1	4.3	3.3	2.4	1.4	0.6	9.6	9.6	10.0	8.0	8.0	5.2	144	136	90	86	60	37	13	11
II. Muk Kampul floodplain	1,180	1957	10.1	9.6	0.5	830	3.9	3.4	1.6	1.1	-	-	17.5	14.0	22.3	19.4	-	-	135	140	67	54	-	-	4	5
		1963	10.7	9.5	1.2	820	4.5	3.3	2.2	1.0	-	-	21.9	12.4	34.4	18.3	8.1	-	141	136	86	64	7	-	4	4
		1961	12.2	10.9	1.3	920	6.0	4.7	3.7	2.5	1.5	0.3	5.6	6.0	42.5	39.5	22.5	7.3	148	>	100	87	61	10	7	7
		1940	12.7	11.7	1.0	960	6.5	5.5	4.2	3.2	2.0	1.0	8.7	6.9	23.8	32.3	20.4	13.5	138	129	95	79	49	31	5	5
III. Tonle Toch terrace	1,480	1957	9.7	9.4	0.3	560	2.4	2.1	0.8	0.6	-	-	24.4	15.2	13.9	11.3	-	-	106	101	30	19	-	-	4	4
		1963	10.2	9.4	0.8	560	2.9	2.1	1.3	0.6	0.1	-	32.4	21.7	18.1	9.4	-	-	114	106	53	21	2	-	5	5
		1961	11.5	10.3	1.2	745	4.2	3.0	2.5	1.4	0.9	0.1	19.3	19.0	29.0	27.5	16.6	3.2	128	130	79	58	51	3	6	5
		1940	12.1	11.0	1.1	910	4.8	3.7	3.2	2.1	1.5	0.5	11.1	11.0	17.0	16.0	13.0	6.9	122	109	70	54	43	21	5	5
IV. Prey Veng floodplain	1,730	1957	6.9	6.4	0.5	1,140	2.5	2.0	0.8	0.38	-	-	13.1	12.1	13.3	12.6	-	-	132	123	48	24	-	-	6	6
		1963	7.4	6.5	0.9	1,160	3.0	2.1	1.3	0.4	-	-	18.1	11.1	15.8	12.8	-	-	131	122	69	26	1	-	5	5
		1961	9.3	7.6	1.7	1,425	4.9	3.2	3.2	1.5	1.4	0.5	10.2	8.3	26.2	19.6	17.7	1.4	140	147	86	61	62	2	8	9
		1940	9.9	8.7	1.2	1,660	5.5	4.3	3.8	2.6	2.0	0.9	7.9	7.6	18.6	17.0	10.9	6.3	129	120	80	63	52	30	6	6
V. Plain of Reeds	850	1957	4.3	3.8	0.5	400	1.6	1.1	0.3	-	-	-	10.8	9.9	5.7	5.4	-	-	113	92	51	-	-	-	8	13
		1963	4.7	3.9	0.8	425	2.0	1.2	0.7	-	-	-	8.1	6.1	6.5	1.2	-	-	117	101	70	-	-	-	10	6
		1961	6.1	5.0	1.1	545	3.4	2.3	2.1	1.0	0.9	-	12.0	7.5	12.0	7.2	3.4	-	146	150	86	73	54	-	9	15
		1940	6.5	5.6	0.9	560	3.8	2.9	2.5	1.6	1.2	0.3	5.4	6.6	10.2	7.8	6.8	3.1	129	117	77	60	48	24	8	8
VI. Kandal island	1,330	1957	5.9	5.4	0.5	770	2.6	2.2	1.2	0.8	0.2	-	15.8	12.2	15.7	15.9	2.5	9.0	92	85	80	68	17	2	12	9
		1963	6.2	5.4	0.8	770	3.0	2.2	1.6	0.8	0.3	0.6	19.9	11.1	18.0	16.4	2.4	7.0	129	143	104	81	23	7	17	10
		1961	7.2	6.4	0.8	995	3.9	3.2	2.4	1.8	1.2	0.4	10.9	9.1	23.2	20.8	6.1	4.1	148	148	106	98	75	40	12	23
		1940	7.3	6.8	0.5	1,080	4.1	3.5	2.7	2.1	1.3	0.8	10.9	9.6	13.2	14.0	6.3	4.2	124	118	99	87	63	44	13	13
VII. Takeo depression	2,720	1957	4.8	4.4	0.4	1,220	2.2	1.8	0.9	0.5	0.1	0	10.9	11.5	8.9	7.2	0.1	0.1	105	113	69	42	7	1	12	11
		1963	5.1	4.4	0.7	1,220	2.5	1.8	1.2	0.5	0.1	0.1	10.6	8.6	7.4	5.2	0.7	0	138	115	93	50	9	3	20	12
		1961	6.1	5.3	0.8	1,640	3.4	2.7	2.1	1.4	0.8	0.2	6.7	6.4	10.6	8.1	5.0	2.2	>	>	111	108	56	22	15	20
		1940	6.2	5.7	0.5	1,765	3.6	3.0	2.3	1.7	1.0	0.5	9.9	9.7	7.8	7.1	5.3	3.5	141	136	96	84	56	37	13	13

Nat. : Natural ; PM : With Pa Mong ; - : No inundation ; > : Over 150 days

* Great Lake water surface area is excluded.

Appendix 2C Average Hydrologic Values With and Without Pa Mong (250 P+F)

Land Unit	Total area of land unit	Year analyzed	Peak sustained water level		Max. Draw-down of W.L.	Area free from inundation by Pa Mong	Max. Water depth						Max. Rate of rising water level						Duration of inundation						Period of keeping peak sustained W.L.	
							Lowland		Medium		Highland		Lowland		Medium		Highland		Lowland		Medium		Highland			
							Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM		
	(km²)		(m)		(m)	(km²)	(m)		(m)		(m)		(cm/day)		(cm/day)		(cm/day)		(days)		(days)		(days)		(days)	
I.	17,690	1957	8.7	8.3	0.4	12,070	3.2	2.8	1.3	0.9	0	0	12.0	11.1	8.0	6.2	0	0	148	146	73	63	0	0	13	12
Tonle Sap	(14,690)*	1963	9.2	8.4	0.8	12,090	3.7	2.9	1.8	1.0	0	0	13.0	9.3	7.2	5.3	0	0	143	134	96	76	-	6	10	10
floodplain		1961	10.6	9.9	0.7	15,050	5.1	4.4	3.2	2.5	1.3	0.7	7.7	7.4	11.0	9.7	5.4	5.6	>	>	107	97	65	41	10	16
		1940	10.7	10.0	0.7	15,060	5.1	4.5	3.3	2.6	1.4	0.8	9.6	8.9	10.0	9.3	8.0	5.4	144	146	90	88	60	15	13	14
II.	1,180	1957	10.1	9.7	0.4	835	3.9	3.5	1.6	1.3	-	-	17.5	14.4	22.3	21.8	-	-	135	140	67	58	-	-	4	5
Muk Kampul		1963	10.7	9.8	0.9	840	4.5	3.6	2.2	1.4	-	-	21.9	17.4	34.4	27.4	8.1	-	141	135	86	69	7	-	4	4
floodplain		1961	12.2	11.5	0.7	950	6.0	5.3	3.7	3.1	1.5	0.8	5.6	6.3	42.5	39.8	22.5	15.8	148	>	100	85	61	29	7	6
		1940	12.7	12.1	0.6	975	6.5	5.9	4.2	3.6	2.0	1.3	8.7	8.1	23.8	30.0	20.4	13.0	138	126	95	79	49	38	5	5
III.	1,480	1957	9.7	9.5	0.2	580	2.4	2.2	0.8	0.7	-	-	24.4	20.9	13.9	18.4	-	-	106	94	30	20	-	-	4	5
Tonle Toch		1963	10.2	9.6	0.6	595	2.9	2.3	1.3	0.7	0.1	-	32.4	20.0	18.1	18.8	-	-	114	108	53	25	2	-	5	6
terrace		1961	11.5	10.8	0.7	860	4.2	3.4	2.5	1.8	0.9	0.3	19.3	18.7	29.0	25.6	16.6	7.3	128	128	79	70	51	15	6	6
		1940	12.1	11.3	0.8	990	4.8	4.0	3.2	2.4	1.5	0.8	11.1	12.7	17.0	19.0	13.0	10.0	122	113	70	58	13	31	5	5
IV.	1,730	1957	6.9	6.6	0.3	1,180	2.5	2.2	0.8	0.5	-	-	13.1	14.1	13.3	14.5	-	-	132	119	48	26	-	-	6	6
Prey Veng		1963	7.4	6.7	0.7	1,200	3.0	2.3	1.3	0.6	-	-	18.1	10.4	15.8	16.6	-	-	131	92	69	34	1	-	5	5
floodplain		1961	9.3	8.4	0.9	1,600	4.9	4.0	3.2	2.3	1.4	0.6	10.2	8.6	26.2	21.1	17.7	9.1	140	>	86	78	62	26	8	6
		1940	9.9	9.1	0.8	1,730	5.5	4.7	3.8	3.0	2.0	1.2	7.9	8.1	18.6	18.6	10.9	9.6	129	127	80	66	52	40	6	8
V.	850	1957	4.3	4.0	0.3	447	1.6	1.2	0.3	0	-	0	10.8	10.4	5.7	6.0	-	-	113	93	51	8	-	-	8	13
Plain of		1963	4.7	4.1	0.6	457	2.0	1.3	0.7	0.1	-	0	8.1	6.8	6.5	6.0	-	-	117	116	70	19	-	-	10	8
Reeds		1961	6.1	5.5	0.6	555	3.4	2.8	2.1	1.5	0.9	0.2	12.0	7.8	12.0	10.0	3.4	3.4	146	>	86	83	54	22	9	9
		1940	6.5	5.8	0.7	565	3.8	3.1	2.5	1.8	1.2	0.6	5.4	6.4	10.2	9.0	6.8	5.2	129	121	77	65	48	35	8	12
VI.	1,330	1957	5.9	5.6	0.3	820	2.6	2.3	1.2	0.9	0.2	0.1	15.8	15.1	15.7	15.4	2.5	1.3	92	108	80	72	17	4	12	10
Kandal		1963	6.2	5.8	0.4	870	3.0	2.8	1.6	1.5	0.3	0.3	19.9	26.2	18.0	30.7	2.4	8.1	129	128	104	90	23	11	17	14
island		1961	7.2	6.7	0.5	1,060	3.9	3.5	2.4	2.1	1.2	0.7	10.9	10.1	23.2	26.2	6.1	5.4	148	141	106	107	75	52	12	16
		1940	7.3	6.9	0.4	1,100	4.1	3.7	2.7	2.3	1.3	0.9	10.9	10.1	13.2	16.7	6.3	5.7	124	118	99	95	63	52	13	18
VII.	2,720	1957	4.8	4.5	0.3	1,265	2.2	1.8	0.9	0.6	0.1	-	10.9	11.4	8.9	7.8	0.1	1.0	105	90	69	49	7	3	12	11
Takeo		1963	5.1	4.6	0.5	1,325	2.5	1.9	1.2	0.7	0.1	-	10.6	9.6	7.4	7.0	0.7	0.4	138	135	93	69	9	6	20	18
depression		1961	6.1	5.6	0.5	1,740	3.4	3.0	2.1	1.7	0.8	0.6	6.7	5.3	10.6	8.9	5.0	3.8	>	135	111	115	56	40	15	19
		1940	6.2	5.8	0.4	1,800	3.6	3.2	2.3	1.9	1.0	0.6	9.9	9.1	7.8	8.3	5.3	4.5	141	142	96	88	56	41	13	17

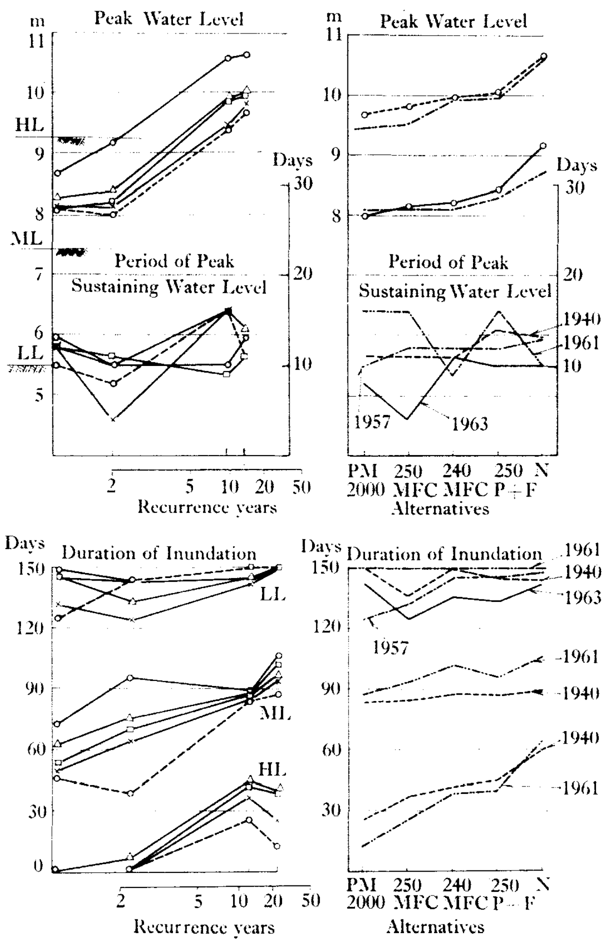
Nat. : Natural ; PM : With Pa Mong ; - : No inundation ; > : Over 150 days
* Great Lake water surface area is excluded.

Appendix 2D Average Hydrologic Values With and Without Pa Mong (240 MFC)

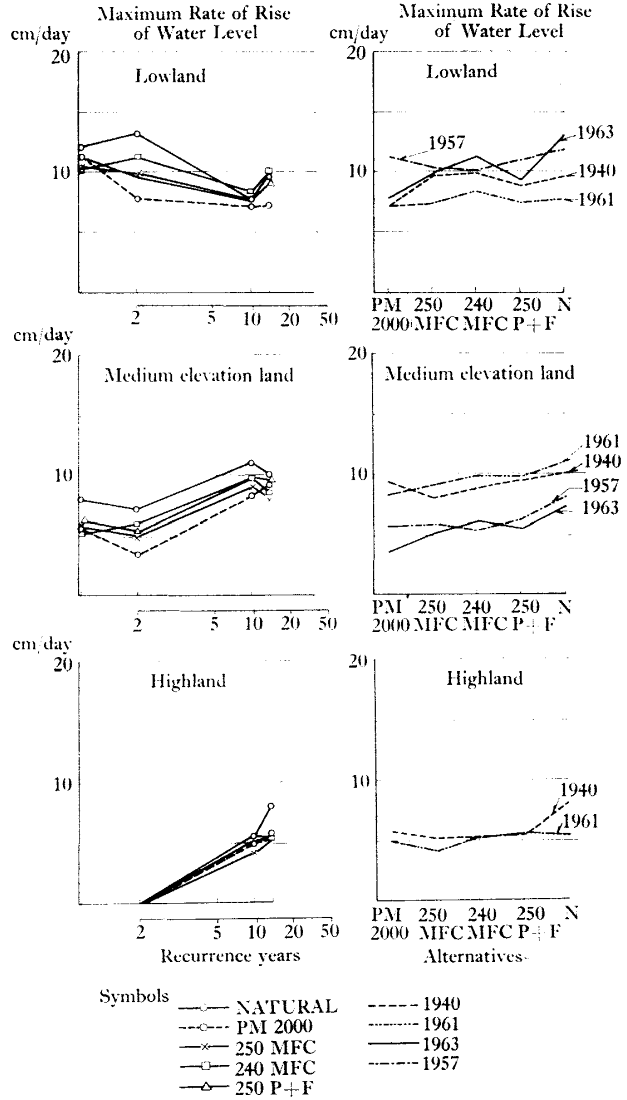
Land Unit	Total area of land unit (km²)	Year analyzed	Peak sustained water level (m)		Max. Draw-down of W.L. (m)	Area free from inundation by Pa Mong (km²)	Max. Water depth Lowland (m)		Max. Water depth Medium (m)		Max. Water depth Highland (m)		Max. Rate of rising water level Lowland (cm/day)		Max. Rate of rising water level Medium (cm/day)		Max. Rate of rising water level Highland (cm/day)		Duration of inundation Lowland (days)		Duration of inundation Medium (days)		Duration of inundation Highland (days)		Period of keeping peak sustained W.L. (days)	
							Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM	Nat.	PM		
I. Tonle Sap floodplain	17,690 (14,690)*	1957	8.7	8.1	0.6	12,040	3.2	2.6	1.3	0.7	-	-	12.0	10.1	8.0	5.2	-	-	148	145	73	54	-	-	13	12
		1963	9.2	8.2	1.0	12,055	3.7	2.7	1.8	0.8	-	-	13.0	11.2	7.2	5.9	-	-	143	136	96	71	-	-	10	4
		1961	10.6	9.9	0.7	15,050	5.1	4.4	3.2	2.5	1.3	0.7	7.7	8.3	11.0	9.8	5.4	5.2	>	>	107	103	65	39	10	16
		1940	10.7	10.0	0.7	15,060	5.1	4.5	3.3	2.6	1.4	0.7	9.6	9.9	10.0	8.8	8.0	5.3	144	149	90	89	60	42	13	11
II. Muk Kampul floodplain	1,180	1957	10.1	9.6	0.5	830	3.9	3.4	1.6	1.2	-	-	17.5	14.8	22.3	20.7	-	-	135	141	67	53	-	-	4	4
		1963	10.7	10.1	0.6	865	4.5	3.8	2.2	1.6	-	-	21.9	18.8	34.4	31.5	8.1	-	141	129	86	70	7	-	4	4
		1961	12.2	11.5	0.7	950	6.0	5.3	3.7	3.0	1.5	0.7	5.6	6.6	42.5	42.0	22.5	16.6	148	148	100	91	61	43	7	6
		1940	12.7	11.7	1.0	960	6.5	5.5	4.2	3.3	2.0	1.0	8.7	8.7	23.8	24.7	20.4	18.0	138	144	95	82	49	38	5	8
III. Tonle Toch terrace	1,480	1957	9.7	9.5	0.2	580	2.4	2.2	0.8	0.6	-	-	24.4	19.4	13.9	9.5	-	-	106	102	30	18	-	-	4	5
		1963	10.2	9.8	0.4	640	2.9	2.5	1.3	0.9	0.1	-	32.4	33.8	18.1	17.6	-	-	114	110	53	29	2	-	5	6
		1961	11.5	10.7	0.8	840	4.2	3.4	2.5	1.8	0.9	0.2	19.3	21.7	29.0	28.3	16.6	7.2	128	127	79	67	51	19	6	6
		1940	12.1	11.1	1.0	930	4.8	3.8	3.2	2.1	1.5	0.5	11.1	11.2	17.0	17.9	13.0	7.2	122	115	70	58	43	28	5	6
IV. Prey Veng floodplain	1,730	1957	6.9	6.6	0.3	1,180	2.5	2.2	0.8	0.5	-	-	13.1	12.3	13.3	11.3	-	-	132	130	48	26	-	-	6	5
		1963	7.4	6.9	0.5	1,245	3.0	2.5	1.3	0.8	-	-	18.1	19.9	15.8	14.1	-	-	131	132	69	36	1	-	5	6
		1961	9.3	8.4	0.9	1,600	4.9	3.9	3.2	2.2	1.4	0.5	10.2	10.2	26.2	25.0	17.7	7.6	140	146	86	78	62	27	8	7
		1940	9.9	8.8	1.1	1,680	5.5	4.4	3.8	2.7	2.0	1.0	7.9	10.2	18.6	19.0	10.9	6.2	129	123	80	67	52	38	6	8
V. Plain of Reeds	850	1957	4.3	3.9	0.4	425	1.6	1.2	0.3	-	-	-	10.8	10.2	5.7	5.8	-	-	113	106	51	-	-	-	8	9
		1963	4.7	4.2	0.5	465	2.0	1.5	0.7	0.2	-	-	8.1	10.1	6.5	5.0	-	-	117	122	70	15	-	-	10	7
		1961	6.1	5.4	0.7	555	3.4	2.7	2.1	1.4	0.9	0.2	12.0	8.2	12.0	10.5	3.4	2.5	146	140	86	78	54	16	9	8
		1940	6.5	5.7	0.8	560	3.8	3.0	2.5	1.7	1.2	0.4	5.4	5.2	10.2	9.4	6.8	2.5	129	117	77	63	48	30	8	13
VI. Kandal island	1,330	1957	5.9	5.4	0.5	770	2.6	2.2	1.2	0.8	0.2	-	15.8	14.3	15.7	14.3	2.5	-	92	94	80	72	17	6	12	8
		1963	6.2	5.6	0.6	820	3.0	2.4	1.6	1.0	0.3	0.1	19.9	13.1	18.0	19.6	2.4	1.3	129	129	104	89	23	9	17	9
		1961	7.2	6.7	0.5	1,060	3.9	3.5	2.4	2.1	1.2	0.7	10.9	10.6	23.2	20.9	6.1	5.5	148	148	106	101	75	55	12	14
		1940	7.3	6.8	0.5	1,080	4.1	3.6	2.7	2.2	1.3	0.8	10.9	11.8	13.2	12.3	6.3	4.8	124	126	99	92	63	50	13	18
VII. Takeo depression	2,720	1957	4.8	4.4	0.4	1,220	2.2	1.8	0.9	0.5	0.1	-	10.9	11.6	8.9	6.7	0.1	0.1	105	117	69	52	7	3	12	11
		1963	5.1	4.5	0.6	1,265	2.5	1.9	1.2	0.6	0.1	-	10.6	10.7	7.4	6.4	0.7	0.5	138	131	93	68	9	5	20	11
		1961	6.1	5.6	0.5	1,740	3.4	3.0	2.1	1.7	0.8	0.4	6.7	8.9	10.6	9.7	5.0	3.5	>	147	111	102	56	35	15	15
		1940	6.2	5.8	0.4	1,800	3.6	3.1	2.3	1.8	1.0	0.6	9.9	8.3	7.8	7.5	5.3	3.8	141	136	96	84	56	41	13	17

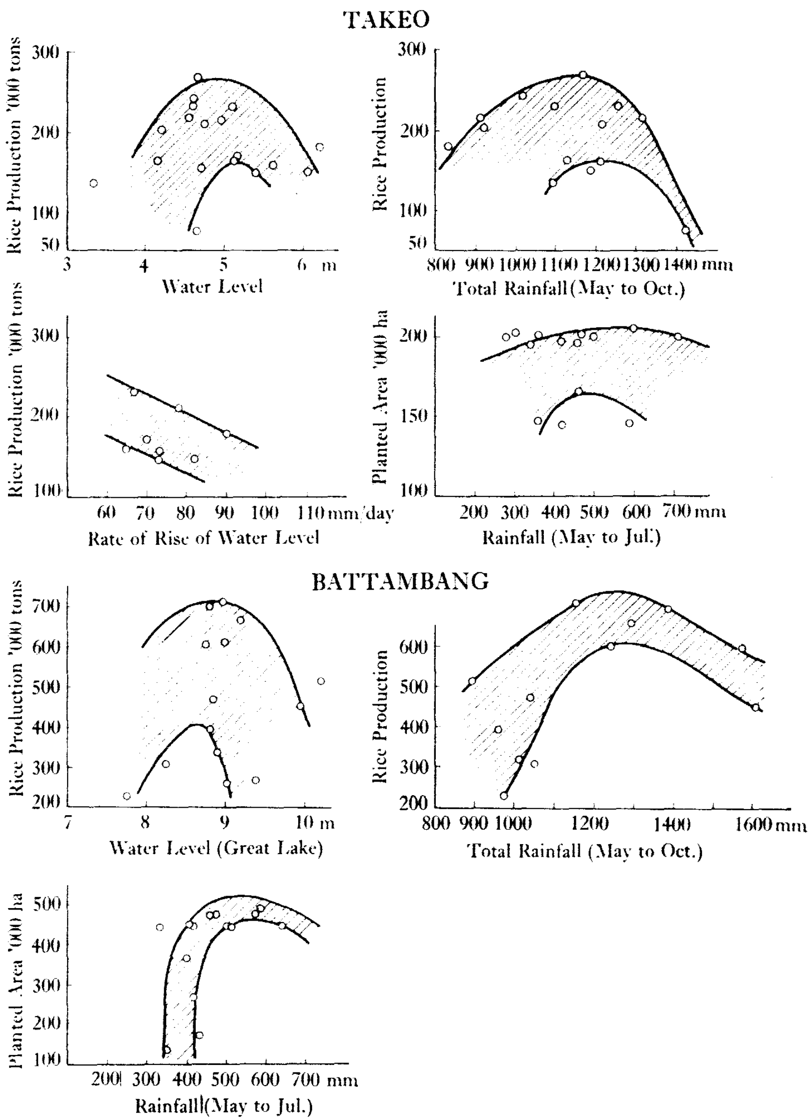
Nat. : Natural ; PM : With Pa Mong ; - : No inundation ; > : Over 150 days

* Great Lake water surface area is excluded.

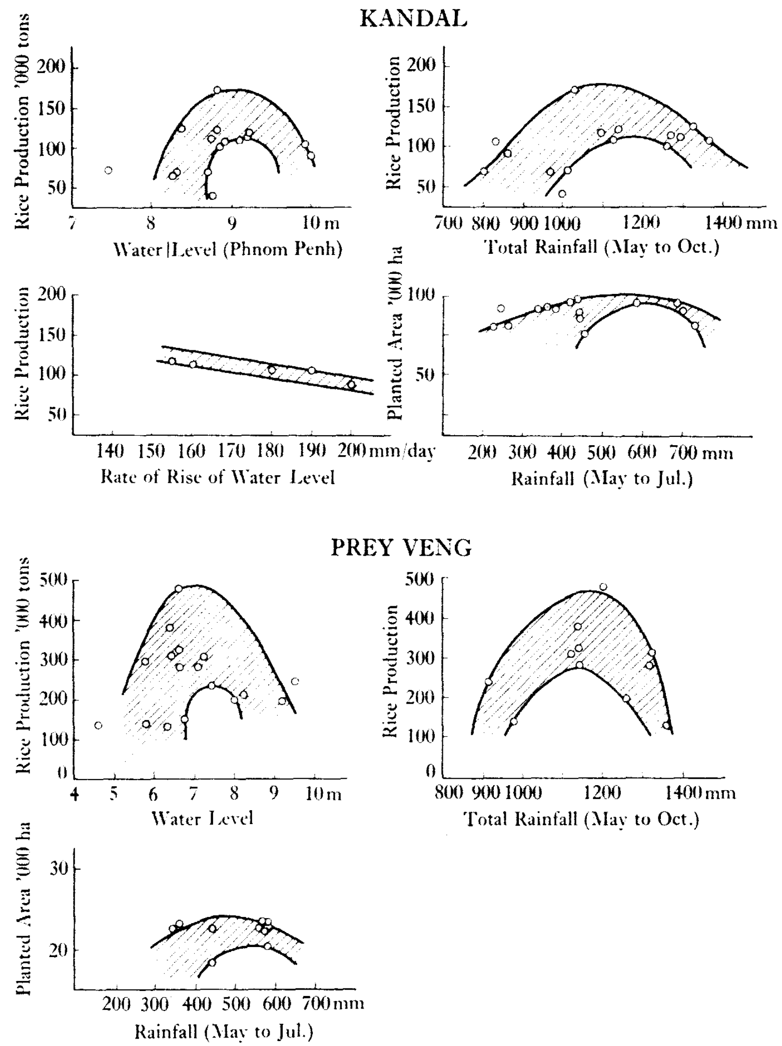


Appendix 3 Average Hydrologic Characters in Land Unit I (Tonle Sap Floodplain): An Example





Appendix 4A Rice Production as Related to Water Regimes in Takeo and Battambang Provinces



Appendix 4B Rice Production as Related to Water Regimes in Kandal and Prey Veng Provinces
Data source: Ref. 13 and 15.

Appendix 5 Net Floating and Late Maturing Rice Areas With and Without Pa Mong

Unit : km^2

Land unit	NATURAL		P M 2000								250 M F C							
			Floating rice				Late maturing rice				Floating rice				Late maturing rice			
	F R	L M R	Extended area	New area	F R ↓ F R	Total	F R ↓ L M R	New area	L M R ↓ L M R	Total	Extended area	New area	F R ↓ F R	Total	F R ↓ L M R	New area	L M R ↓ L M R	Total
I. Tonle Sap floodplain	2,466	1,783	1,593	56	1,002	2,651	1,332	0	350	1,682	1,423	51	1,117	2,591	1,229	0	453	1,682
II. Muk Kampul floodplain	15	2	20	87	5	112	11	0	0	11	20	141	5	166	11	44	2	57
III. Tonle Toch terrace	26	28	0	0	0	0	0	0	2	2	0	0	0	0	0	21	2	23
IV. Prey Veng floodplain	274	16	111	74	64	249	14	106	0	120	88	94	98	280	13	94	3	110
V. Plain of Reeds	277	201	0	0	59	59	199	0	80	279	0	0	89	89	192	0	92	284
VI. Kandal island	65	88	51	12	33	96	26	132	9	167	51	95	35	181	23	44	8	75
VII. Takeo depression	376	426	176	12	183	371	236	0	107	343	154	28	202	384	278	0	140	418
Total	3,499	2,544	1,951	241	1,346	3,538	1,818	238	548	2,604	1,736	409	1,546	3,691	1,746	203	700	2,649
	NATURAL		240 M F C								250 P+F							
I. Tonle Sap floodplain	2,466	1,783	1,059	19	1,483	2,561	870	19	788	1,677	911	0	1,675	2,586	733	0	916	1,649
II. Muk Kampul floodplain	15	2	13	20	9	42	0	0	0	0	13	44	9	66	0	41	0	41
III. Tonle Toch terrace	26	28	6	0	14	20	0	0	2	2	6	0	14	20	0	0	2	2
IV. Prey Veng floodplain	274	16	49	0	140	189	10	59	5	74	81	24	177	282	10	61	5	76
V. Plain of Reeds	277	201	2	0	112	114	67	0	109	176	0	0	160	160	118	0	145	263
VI. Kandal island	65	88	47	99	54	200	15	0	10	25	43	21	51	115	13	0	11	24
VII. Takeo depression	376	426	140	32	241	413	189	0	220	409	140	35	258	433	158	0	197	355
Total	3,499	2,544	1,316	170	2,053	3,539	1,151	78	1,134	2,363	1,194	124	2,344	3,662	1,032	102	1,276	2,410

FR : Floating rice : LMR : Late maturing rice